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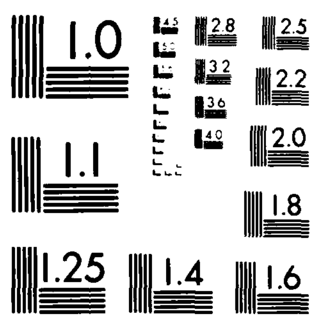
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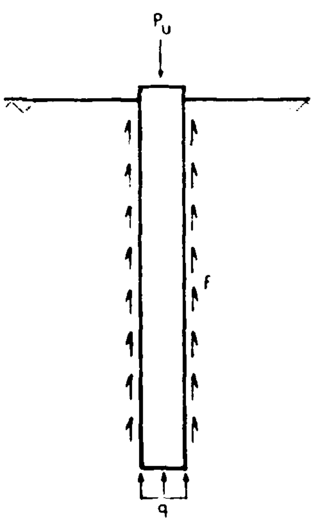

INSTRUCTION REPORT K-84-4

USER'S GUIDE: COMPUTER PROGRAM FOR SOIL-STRUCTURE INTERACTION ANALYSIS OF AXIALLY LOADED PILES (CAXPILE)

by

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February 1984

Final Report

Prepared for Office, Chief of Engineers, U. S. Army
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report documents a computer program--CAXPILE--for the analysis of axially loaded piles in which the load applied to the top of the piles is resisted by a combination of skin friction and tip bearing. The report:

a) Describes the pile-soil system and the assumptions used in the analysis.

b) Presents the procedures used to generate nonlinear force-

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20. ABSTRACT (Continued)

displacement curves from soils data,

c. Outlines the method of solution,

d. Presents example solutions obtained with the program.

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PROGRAM INFORMATION

Description of Program

CAXPILE, called XØØ6Ø in the Conversationally Oriented Real-Time Program-Generating System (CORPS) Library, is a computer program for the soil-structure interaction analysis of axially loaded piles. The model employed for the analysis of the pile-soil system is a special case of a general beam-column with the soil modeled by linear and/or nonlinear springs. It is intended to be an easy-to-use program incorporating the capabilities required by a diverse group of users. CAXPILE utilizes the finite element method of structural analysis to model the pile.

Coding and Data Format

CAXPILE is written in FORTRAN and is operational on the following systems:

a. WES Honeywell DPS/1.

b. Harris 500 computers which are located at most district Corps offices.

c. Control Data Corporation, Cybernet Computer Service's CDC CYBER systems.

Data can be input either interactively at execute time or from a prepared data file with line numbers. Output may be directed to an output file or come directly back to the terminal.

How to Use CAXPILE

A short description of how to access the program on each of the three systems is provided below. It is assumed that the user knows how to sign on the appropriate system before trying to use CAXPILE. In the example initiation of execution commands below, all user responses are underlined, and each should be followed by a carriage return.

WES Honeywell System

After the user has signed on the system, the two system commands FORT and NEW get the user to the level to execute the program. Next, the user issues the run command

RUN WESLIB/CORPS/XØØ6Ø,R

to initiate execution of the program. The program is then run as described in this user's guide. The data file should be prepared prior to issuing the RUN command. An example initiation of execution is as follows, assuming a data file had previously been prepared:

```
HIS SERIES 600 ON 03/04/81 AT 13.301 CHANNEL 5647
USER ID - ROKACASECON
PASSWORD - XXXXXXXXXXXXXX
SYSTEM? FORT NEW
READY
*RUN WESLIB/CORPS/XØØ6Ø,R
```

CDC, Cybernet System

The log-on procedure is followed by a call to the CORPS procedure file

OLD, CORPS/UN=CECELB

to access the CORPS Library. The file name of the program is used in the command

BEGIN,,CORPS,XØØ6Ø

to initiate execution of the program. An example is:

```
S4/01/25 10.32.51  AC2E5DA
EASTERN CYBERNET CENTER SN487 NOS        1.4/531.281/20AD
FAMILY: KOE
USER NAME: CEROC2
PASSWORD -
XXXXXXX
TERMINAL:     510, NAMIAF
RECOVER/CHARGE: CHARGE, CEXXXXX, YYYYYY
/OLD, CORPS/UN=CECELB
/BEGIN,,CORPS/XØØ6Ø
```

Local District Harris Systems

After the user has signed on the system, the command to execute the CORPS program will be

*CORPS,XØØ6Ø

An example to illustrate the log-on and execution procedure on one Harris 500 is shown below. There may be some differences at some local Corps sites.

```
"ACOE - VICKSBURG"
USER #? NNNNWES WESXXX
```

** Good Morning 25 Jan 84 9:56:31
VED HARRIS 500

*CORPS,XØØ6Ø

How to Use CORPS

The CORPS system contains many other useful programs which may be catalogued from CORPS by use of the LIST command. The execute command for CORPS on the WES system is:

```
RUN WESLIB/CORPS/CORPS,R
ENTER COMMAND (HELP,LIST,BRIEF,MESSAGE,EXECUTE, OR STOP)
*?LIST
```

On the Cybernet system, the commands are:

```
OLD,CORPS/UN=CECELB
BEGIN,,CORPS,CORPS
ENTER COMMAND (HELP,LIST,BRIEF,MESSAGE,EXECUTE, OR STOP)
*?LIST
```

On the Harris local systems, the commands are:

```
*CORPS

ARE YOU USING A PRINTER TERMINAL OR CRT?
ENTER P OR C
C

ENTER COMMAND (BRIEF,EXECUTE,LIST,HELP,STOP):
LIST
```

PREFACE

This user's guide provides instructions for using a computer program called CAXPILE that can be a tool in analysis of axially loaded piles in which load applied to the top (head) of the pile is resisted by a combination of skin friction and point (tip) bearing. Some criteria used in the program, although the best available, are not adequately verified by field tests. Therefore, good engineering judgment is required in the use of this program.

The work in writing the computer program and the user's guide was accomplished with funds provided to the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss., by the Civil Works Research and Development Program of the Office, Chief of Engineers, U. S. Army (OCE), under the Structural Engineering Research Program work unit of the Soil-Structure Interaction (SSI) Studies Project.

The computer program and user's guide were written by Dr. William P. Dawkins, P.E., of Stillwater, Okla., using criteria provided by WES.

Dr. N. Radhakrishnan, Special Technical Assistant, Automatic Data Processing (ADP) Center, WES, and SSI Studies Project Manager, coordinated and monitored the work. Messrs. H. Wayne Jones and Reed L. Mosher, Computer-Aided Design Group, provided technical assistance in developing and evaluating the program. Mr. Donald R. Dressler was the point of contact in OCE.

Commanders and Directors of WES during the development of this program were COL N. P. Conover, CE, and COL T. C. Creel, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC)
UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
feet	0.3048	meters
inches	0.0254	meters
kips (1000 lb force)	4.448222	kilonewtons
pounds (force) per foot	14.59390	newtons per meter
pounds (force) per square foot	47.88026	pascals
pounds (force) per square inch	6.894757	kilopascals
pounds (mass) per cubic foot	16.01846	kilograms per cubic meter
square inches	0.00064516	square meters
tons (2000 lb force) per square foot	95.76052	kilopascals

USER'S GUIDE: COMPUTER PROGRAM FOR SOIL-STRUCTURE INTERACTION ANALYSIS OF AXIALLY LOADED PILES (CAXPILE)*

PART I: INTRODUCTION

General Program Description

1. This report describes a computer program--CAXPILE--for analysis of axially loaded piles in which the load applied to the top (head) of the pile is resisted by a combination of skin friction and point (tip) bearing. The axially loaded pile is a special case of a beam-column with nonlinear supports. CAXPILE is a special-purpose application of the general-purpose, beam-column analysis program CBEAMC (Reference 1).

2. The relationship between side friction and/or tip force and the displacements of the pile may be provided as nonlinear force-displacement curves or in the form of soil properties. Development of nonlinear force-displacement curves is described in Reference 2. Only those procedures used internally by the program to convert input soil properties to nonlinear force-displacement curves are described in detail herein.

Organization of Report

3. The remainder of this report is organized as follows:

- a. Part II: Describes the pile-soil system and the assumptions used in the analysis.

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* CAXPILE is designated X0060 in the Conversationally Oriented Real-Time Program-Generating System (CORPS) library. Three sheets entitled "PROGRAM INFORMATION" have been hand-inserted inside the front cover. They present general information on CAXPILE and describe how it can be accessed. If procedures used to access this and other CORPS programs should change, recipients of this report will be furnished revised versions of the "PROGRAM INFORMATION" sheets.

b. Part III: Presents the procedures employed to generate nonlinear force-displacement curves from soils data.

c. Part IV: Outlines the method of solution.

d. Part V: Guide for data input.

e. Part VI: Provides example solutions obtained with the program.

Remarks

4. CAXPILE has been checked for computational accuracy within reasonable limits. However, there may exist unusual situations which were not anticipated which may cause the program to produce questionable results. Criteria for this program were provided by the Corps of Engineers. Although it is the best available, some of these criteria are not verified by test results. In particular, the procedures used to convert soil properties to nonlinear force-displacement curves embody a substantial amount of conjecture, and they must be viewed only as a preliminary approach until they have been verified by extensive comparisons with test results. It is the responsibility of the user to use good engineering judgment to determine the validity of the results.

PART II: PILE-SOIL SYSTEM

General

5. The pile-soil system considered for analysis is shown in Figure 1. Characteristics and assumptions for each of the system components are described below.

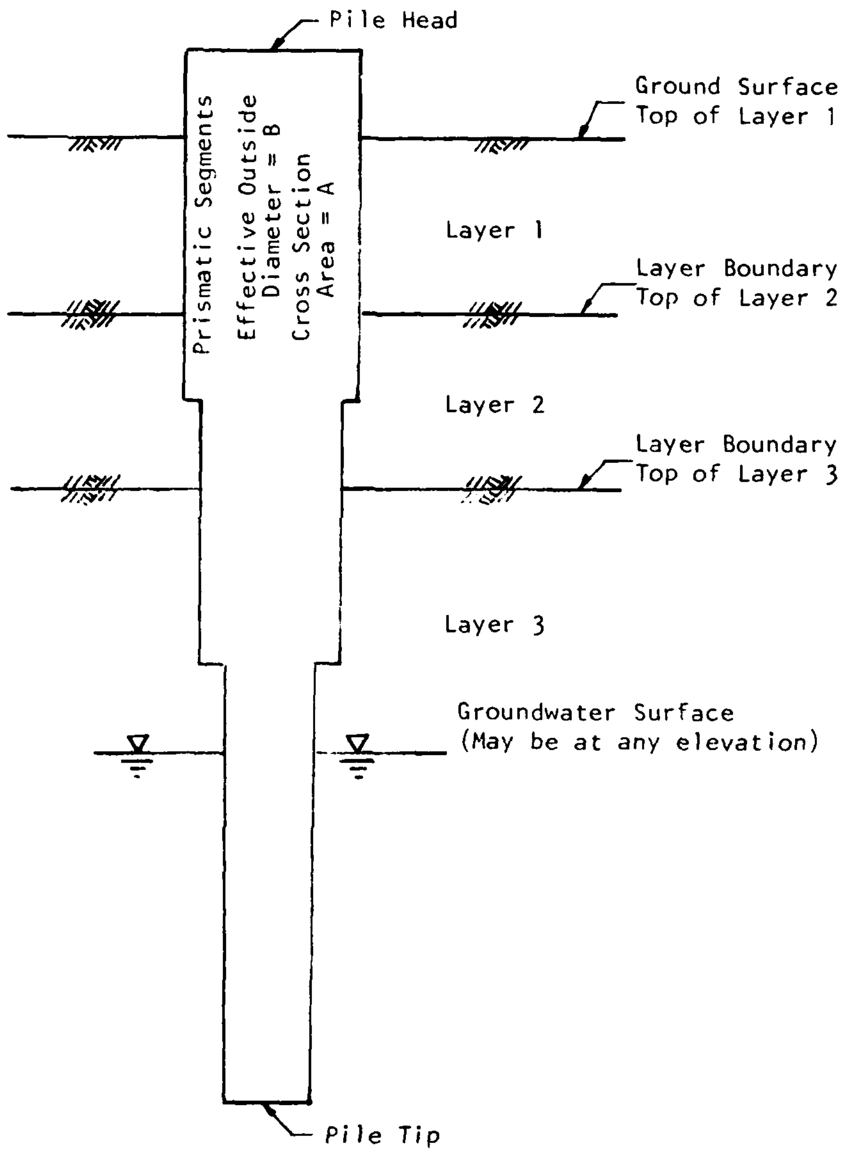

Figure 1. Pile-soil system

Pile

6. The configuration and structural behavior assumed for the pile are:

- a. The pile is vertical and has a straight centroidal axis.
- b. The pile is composed of a sequence of prismatic, homogeneous, linearly elastic segments.
- c. Loading effects are parallel to the axis of the pile and result only in vertical (axial) displacements.
- d. Axial strains produced by axial displacements are "small."

Soil System

7. The soil system surrounding the pile is assumed to possess the following characteristics:

- a. The soil profile is composed of horizontal layers.
- b. A layer may be either cohesive (clay) or cohesionless (sand).
- c. The saturated unit weight of the soil is constant throughout the layer.
- d. Soil properties (angle of internal friction for sand, and cohesion and stress-strain behavior for clay) follow a continuous straight-line variation from top to bottom of a layer.

Groundwater

8. Groundwater is assumed to influence the effective vertical pressure in the soil. Effective unit weight of soil below groundwater elevation is obtained by subtracting the unit weight of water from the unit weight of soil provided as input. Groundwater does not produce any other loading effect.

PART III: SOIL FORCE-DISPLACEMENT CURVES

General

9. The procedures used to convert soil properties to nonlinear force-displacement curves are based on information contained in References 2 through 6. Extrapolation of the basic data to the general pile-soil system considered herein has not been completely substantiated by experiments. Consequently, good engineering judgement must be applied in using the results of this program.

Effective Depth

10. The methodologies contained in the references were based on experimental results for prismatic piles driven into essentially homogeneous soil media. Relationships between forces (side friction and tip reaction) and displacements were expressed in terms of depth for clays or the ratio of depth to pile diameter for sands. Because the soil media were homogeneous, depths used for correlation were actual distances below ground surface.

11. In order to extend the force-displacement relationships reported in the literature to nonprismatic piles in layered soil systems, an "effective" depth or "effective" depth to diameter ratio is defined at any point on the pile as follows:

- a. The effective vertical soil pressure, including the buoyant effect of groundwater, is determined for the point of interest.
- b. The "effective" depth at the point is equal to the effective vertical pressure divided by the effective unit weight of soil at the point. (In essence, the nonhomogeneous medium is replaced by an equivalent homogeneous soil.)
- c. The "effective" depth to diameter ratio is obtained as the ratio of effective depth to diameter of the pile at the point of interest. Note that the depth to diameter ratio defined in this manner will result in dual values in nonprismatic piles at points where abrupt changes in diameter occur.

Side Friction Force-Displacement Curves for Clay

12. The relationship between load transfer (side friction) and displacement was investigated in References 3 and 4 using data from field tests of instrumented piles driven into clay. It was concluded that the force-displacement relationship could be represented by three curves for depths of 0 to 10 ft,* 10 ft to 20 ft, and greater than 20 ft, respectively.

13. Piecewise linear representations (Figure 2) of the three curves presented in References 3 and 4 have been incorporated into CAXPILE. The curves shown in Figure 2 relate the fraction of ultimate side friction (ratio of side friction to soil shear strength) to displacement of the point of interest.

14. References 3 and 4 also indicate that the nominal shear strength (cohesion) of the clay must be adjusted to account for driving effects. The shear strength to be used for determining side friction is obtained by multiplying the nominal cohesion by a shear strength coefficient whose magnitude is a function of the nominal cohesion (see Figure 19, Reference 3). The representation of the shear strength coefficient as a function of nominal cohesion used in CAXPILE is shown in Figure 3.

15. A side friction force-displacement curve for clay at a point on the pile is developed in CAXPILE as follows:

<u>a</u>. The effective vertical soil pressure (p_v), nominal shear strength (C), pile diameter (B), and effective unit soil weight (γ or γ') are determined for the point.

<u>b</u>. The effective depth (D) at the point is obtained from

$$D = p_v/\gamma$$

---

* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 4.

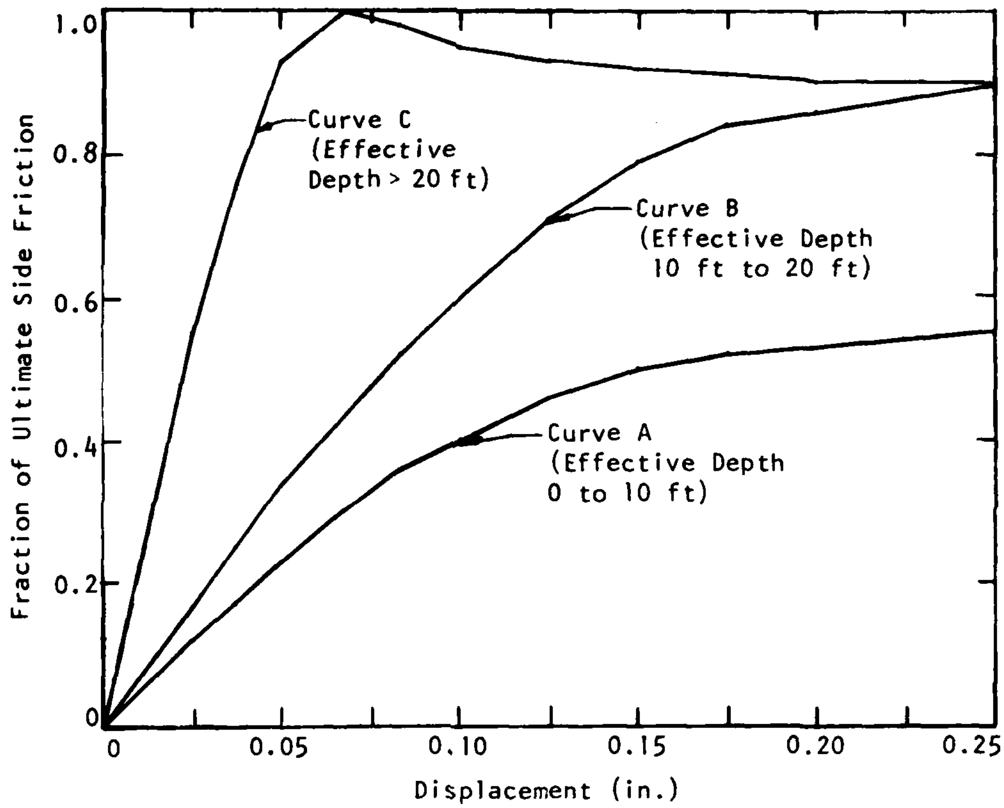

Figure 2. Load transfer curves for clay
(after References 3 and 4)

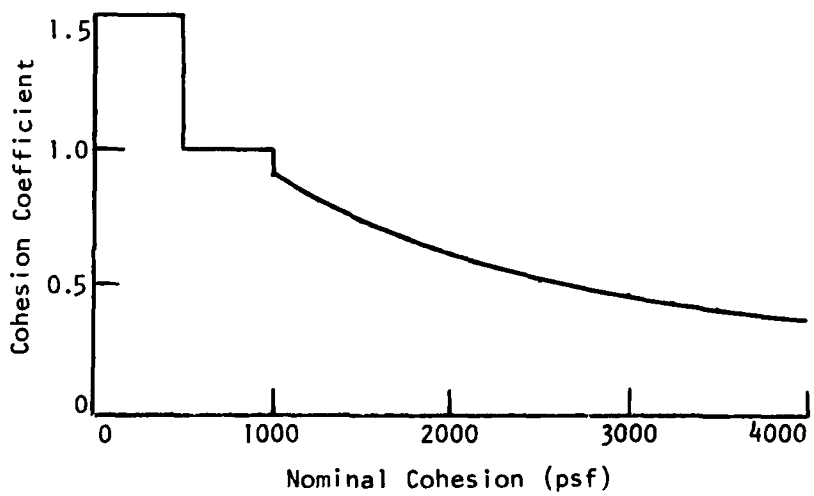

Figure 3. Cohesion adjustment coefficients for
clay (after References 3 and 4)

c. The appropriate load transfer curve (Figure 2) is selected:

(1) Curve A for $0 \leq D \leq 10$ ft.

(2) Curve B for $10 < D < 20$ ft.

(3) Curve C for $D \geq 20$ ft.

d. The shear strength coefficient (K) is determined (Figure 3).

e. The final side friction force-displacement curve is obtained by multiplying the ordinates of the load transfer curve by the force multiplier (FMUL)

$$FMUL = \pi \cdot B \cdot K \cdot C$$

Side Friction Force-Displacement Curves for Sand

16. There are conflicting opinions regarding the relationship between side friction and displacements for piles in sand (Reference 2). The procedures for developing side friction forces incorporated in CAXPILE are only intended to provide an approximate estimate of the pile force-displacement behavior.

17. Because of the conflicting opinions regarding the side friction-displacement relationship for sand, the following assumptions were incorporated in CAXPILE:

a. It is assumed that the proportion of ultimate side friction developed at a given displacement is independent of all other system properties. This results in a single load transfer curve being used for all points in the sand layer. The single curve used in CAXPILE (Figure 4) embodies some of the essential characteristics of the conflicting views (References 2 and 5) but conforms to neither.

b. It is assumed that the ultimate side friction at a point is dependent on the ratio of depth to pile diameter (D/B) and angle of internal friction (ϕ). Figure 24 of Reference 6 provides curves relating ultimate unit side friction to D/B and ϕ. The piecewise linear approximations of these curves for internal friction angles of 30°, 33°, and 37° are shown in Figure 5. In CAXPILE, the depth used

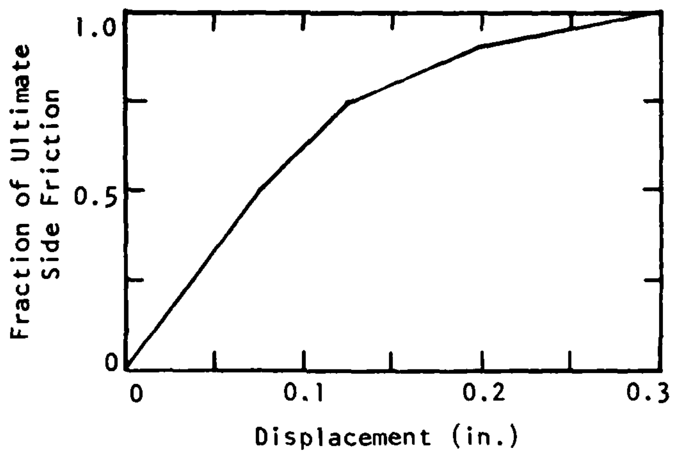

Figure 4. Load transfer curve for sand

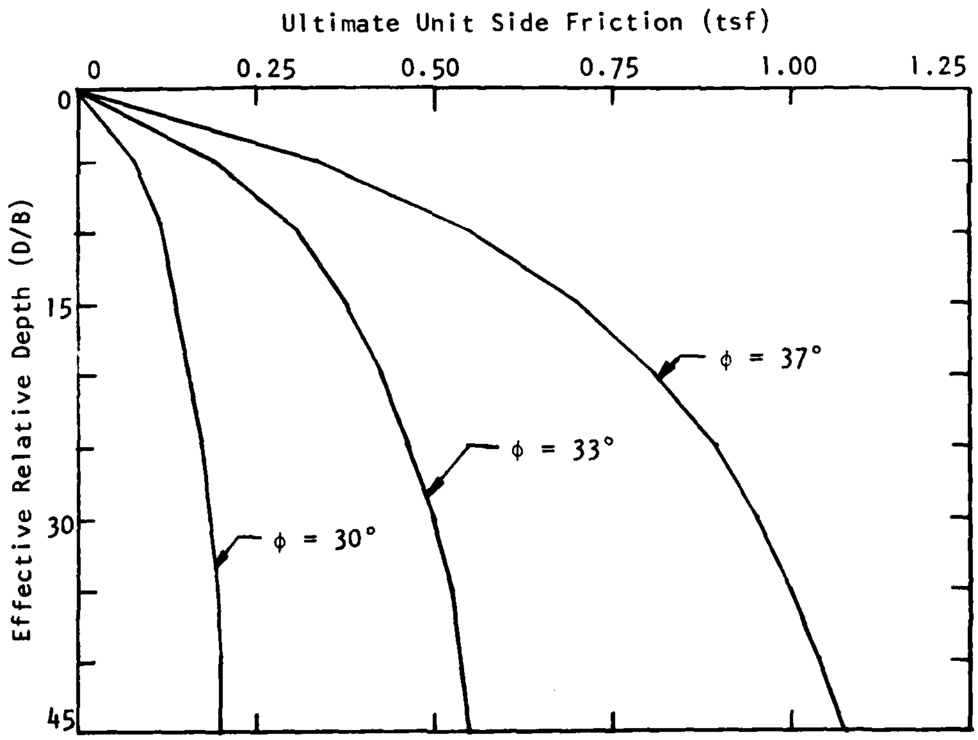

Figure 5. Unit side friction for effective relative depth for sand (after Reference 6)

in determining D/B for these curves is interpreted as the effective depth discussed above. The curves are assumed to produce constant ultimate side friction for values of D/B greater than 45. Ultimate side friction for internal friction angle other than 30°, 33°, and 37° is obtained from a parabolic curve fit of the three curves. Internal friction angles outside the range 30° to 37° may produce results which are significantly in error.

18. A side friction force-displacement curve for sand at a point on the pile is developed in CAXPILE as follows:

- a. The effective vertical soil pressure (p_v), the internal friction angle, pile diameter (B), and effective unit soil weight (γ or γ') are determined at the point.
- b. The effective depth (D) at the point is obtained from

$$D = p_v/\gamma$$

- c. The ultimate side friction (SF) at the point is obtained from the curves shown in Figure 5.
- d. The final side friction force-displacement curve is obtained by multiplying the ordinates of the load transfer curve (Figure 4) by the force multiplier

$$FMUL = \pi \cdot B \cdot SF$$

Number of Side Friction Curves

19. The final force-displacement curve for either sand or clay provides distributed side friction in force per unit length of pile as a function of pile displacement. A number of such curves are generated by the program as follows:

- a. Curves are generated at the top and bottom of each layer.
- b. Two curves are generated at the elevation of each change in diameter of the pile and at groundwater elevation (one immediately above and one immediately below) if either occurs intermediate to the layer boundaries.
- c. In a clay layer, two curves (one above; one below) are generated at the elevation when a transition from curve A to B or B to C occurs in the layer.

d. In a sand layer, single curves are generated at increments of five (5) in effective D/B from top to bottom of the layer.

Tip Reaction

20. CAXPILE offers three alternatives for pile tip reaction: it may be omitted; it may be specified by a tip reaction-displacement curve; or it may be obtained from the soil properties of the layer in which it is embedded.

Tip Reaction-Displacement Curve for Clay

21. The tip reaction-displacement curve for clay is shown in Figure 6. Ultimate tip reaction is assumed to be related to adjusted cohesion (see paragraphs 15 and 16) by

$$p_u = 9 \cdot K \cdot C\pi \cdot B^2/4$$

The displacement at ultimate resistance is assumed to be

$$\Delta_u = 2 \cdot \varepsilon_{50} \cdot B$$

where ε_{50} is the strain at fifty percent of ultimate stress on a soil stress-strain curve.

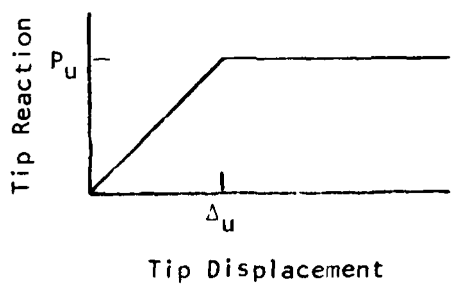

Figure 6. Tip reaction-displacement curve for clay

Tip Reaction-Displacement Curve for Sand

22. Reference 6 provides ultimate unit tip reaction as a function of ratio of depth to pile diameter and internal friction angle (see Figure 22, Reference 6). Piecewise linear approximations of the curves from Reference 6 for unit tip reaction for various values of D/B and ϕ = 30°, 35°, and 38° are shown in Figure 7. A parabolic fit is used for values of ϕ other than 30°, 35°, and 38°. Total ultimate tip reaction is obtained by multiplying the unit tip reaction by the tip area ($\pi B^2/4$).

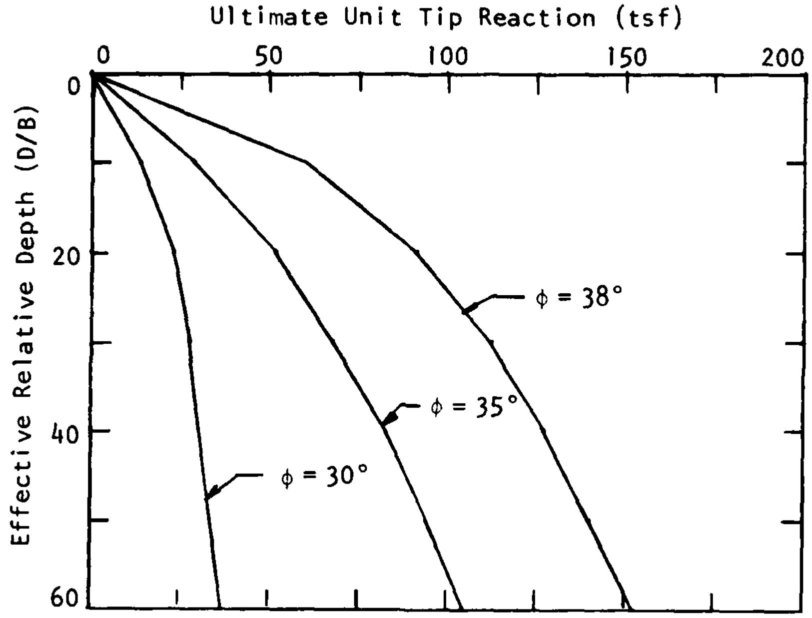

Figure 7. Unit tip reaction for relative depth for sand (after Reference 6)

23. The proportion of ultimate tip reaction developed as a function of tip displacement is shown in Figure 8 and is assumed to be independent of any other system parameters.

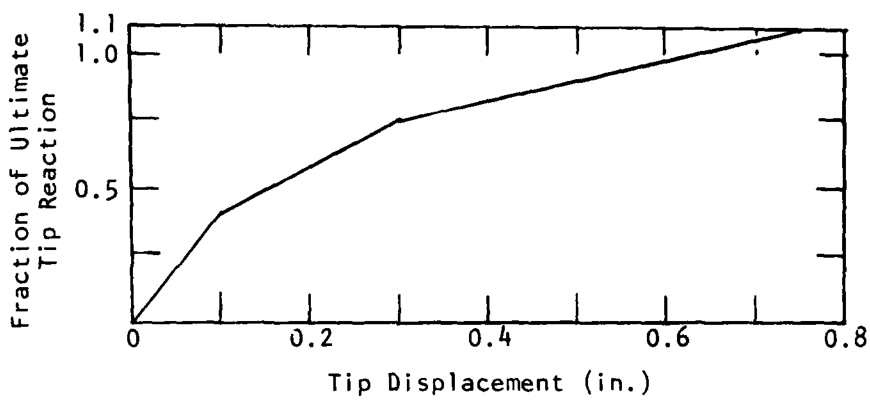

Figure 8. Tip reaction-displacement curve for sand

PART IV: METHOD OF SOLUTION

General

24. As stated previously, the nonlinear side friction or tip reaction force-displacement curves, whether provided as input or generated from soil properties, and the assumed behavior of the pile result in a system which is a special case of a general beam-column on nonlinear supports.

Input Phase

25. CAXPILE accepts input data in a form convenient to the user for describing an axially loaded pile. These input data are converted to a description of a beam-column supported by distributed nonlinear springs representing the side friction force-displacement effects and by a nonlinear concentrated spring representing the tip reaction.

26. Nodes are assigned along the pile at intervals not exceeding 1 ft. The force-displacement effect for side friction at each node is obtained by linear interpolation between successive pairs of the force-displacement curves described in Part III.

Iterative Solutions

27. As explained in Reference 1, a solution for a nonlinear system is obtained from a succession of trial-correction solutions until the results of two successive iterations agree within a prescribed tolerance. When a system contains elements exhibiting softening characteristics (reduction in resistance for increasing deformation), the response for a final loading (or prescribed displacement) must be obtained by applying the loading effect in increments (i.e., the final solution is path dependent).

28. Even though the loading effect is incremented, with iterative solutions obtained for each increment, a unique solution may not be

possible. For example, when the displacement of a point on the pile is in the immediate vicinity of the peak of curve C (Figure 2) successive solutions during iteration may result in displacements which alternate on either side of the peak. When this situation is encountered, the iterative solutions oscillate, and a unique final result is not possible.

Solution Control in CAXPILE

29. The results of field tests reported in the references indicate that the majority of piles, whether driven in sand or clay, reach ultimate load capacity at pile head displacements less than 2 in. Based on this observation, solution control in CAXPILE has been established as follows:

a. Pile head displacement is increased in increments of 0.02 in. until the pile head force begins to decrease or until a maximum pile head displacement of 2 in. is reached.

b. For each increment, iterations are continued until the difference between displacements at every point on the pile is less than 0.001 in. on two successive iterations.

c. In systems containing monotonically increasing force-displacement characteristics, convergence to a final solution for an increment of pile head displacement is usually obtained in three to five iterations. If convergence is not achieved within ten iterations, a perturbation in the displacements is introduced and an additional ten iterations are performed. At the end of twenty iterations, the system is probably oscillating as described in paragraph 28 above. It has been found that the difference in loads and displacements between successive oscillating iterations is usually of practical insignificance. When this situation is encountered, the results for the twentieth iteration for that increment are reported. Even though convergence is not achieved at any one increment, the results for convergent solutions at subsequent increments are unaffected.

Output Phase

30. CAXPILE reports values of force and displacement at the pile

head and tip obtained during the incremental loading described above. The user is then offered the opportunity to output the variation of axial force, axial displacement, and side friction at each interval along the pile for any selected pile head displacement. Plots may also be obtained for the above tabular values.

PART V: GUIDE FOR DATA INPUT

Source of Input

31. Input data may be supplied from a predefined data file or from the user terminal during execution. If data are supplied from the user terminal, prompting messages are printed to indicate the amount and character of data to be entered.

Data Editing

32. When all data for a problem have been entered, the user is offered the opportunity to review an echoprint of the currently available input data and to revise any or all sections of the input data before execution is attempted. When editing during execution, the user must enter each section in its entirety.

Input Data File Generation

33. After data have been entered from the terminal, either initially or after editing, the user may direct the program to write the input data to a permanent file in input data file format.

Data Format

34. All input data (whether supplied from the user terminal or from a file) are read in free-field format; i.e.,

a. Data items must be separated by one or more blanks (comma separators are not permitted).

b. Integer numbers must be of the form NNNN

c. Real numbers may be of the form

$\pm$xxxx, $\pm$xx.xx, or $\pm$xx.xxE$\pm$ee

d. User responses to all requests for control by the program for alphanumeric input may be abbreviated by the first letter of the indicated word response; e.g.,

ENTER 'YES' OR 'NO'--respond Y or N
ENTER 'CONTINUE' OR 'END'--respond C or E

Carriage return responses alone will cause abnormal termination of the program.

Sections of Input

35. Input data are divided into the following sections:

a. Heading.

b. Pile Cross-Section Properties.

c. Side Friction Data.

d. Pile Tip Data.

e. Termination.

36. Data sections must be supplied in the order indicated above.

Predefined Data File

37. In addition to the general format requirements given in paragraph 4 above, the following pertain to a predefined data file and to the input data description which follows:

a. Each line must commence with a nonzero, positive line number, denoted LN below.

b. A line of input may require both alphanumeric and numeric data items. Alphanumeric data items are enclosed in single quotes in the following paragraphs.

c. A line of input may require a keyword. The acceptable abbreviation for the keyword is indicated by an underlined capital letter; e.g., the acceptable abbreviation for the keyword 'Curves' is 'C'.

d. Lowercase words in single quotes indicate a choice defined following.

e. Items designated by uppercase letters and numbers without quotes indicate numeric data values. Numeric data values are either real or integer according to standard FORTRAN variable naming conventions.

f. Data items enclosed in brackets [ ] may not be required. Data items enclosed in braces { } indicate a special note follows.

g. Input data are divided into the sections discussed in paragraph 5 above. Except for the heading, each section consists of a header line and one or more data lines. The header line serves the dual purposes of: indicating the end of the preceding section; identifying the data section to follow.

h. Comment lines may be inserted in the input file by enclosing the line, following the line number, in parentheses. Comment lines are ignored; e.g.,

1234ƀ(THIS LINE IS IGNORED)

Input Description

38. Heading--One (1) to four (4) lines for identifying the problem:

a. Line contents

LN {'heading'}

b. Definition

'heading' = Any alphanumeric information up to 70 characters including LN and any embedded blanks

c. Restriction: If a 'heading' line following LN begins with the first letter of any of the section titles or keywords described below, the 'heading' must begin with a single quote.

39. Pile Cross-Section Properties--One (1) to twenty-one (21) lines:

a. Line 1 contents

LN 'Pile' EL1 EL2 E OD A

b. Lines 2 and following contents

[LN EL1 EL2 E OD A]

c. Definitions

'Pile' = Data section title

EL1 = Elevation (ft) at top of segment

EL2 = Elevation (ft) at bottom of segment

E = Modulus of elasticity (psi) of segment

OD = Outside diameter (in.) of segment

A = Cross-section area (sq in.) of segment

d. Discussion and restrictions

d(1) The pile is assumed to be composed of a sequence of prismatic segments.

d(2) Segments must be defined in succession from pile head to pile tip.

d(3) Elevations decrease toward the tip (bottom) of the pile. On any one line EL2 must be less than EL1. On a succession of lines EL1 must be equal to EL2 on the preceding line.

d(4) The pile head is at EL1 on the first line. The pile tip is at EL2 on the last line.

d(5) The outside diameter (OD) is used to calculate the surface area at a point subjected to side friction or for tip reaction area. For noncircular piles, OD must be the diameter of the equivalent circular pile.

d(6) The cross-section area A is used to determine the axial stiffness of the pile.

40. Side Friction Data--Minimum of two (2) lines:

a. Header--One (1) line

a(1) Contents

LN 'Side' 'keyword' [GAMWAT ELWAT]

a(2) Definitions

'Side' = Data section title

'keyword' = 'Soil' if side friction data are to be obtained from soil layer data

'keyword' = 'Curves' if side friction force-displacement curves are provided

[GAMWAT] = Groundwater unit weight (pcf); omit if 'keyword' = 'Curves'; assumed equal to zero if omitted

[ELWAT] = Groundwater elevation (ft); omit if 'keyword' = 'Curves' or if GAMWAT equals zero

b. Data Lines if 'keyword' = 'Soil'--One (1) to fifteen (15) lines

b(1) Contents for sand layer

LN ELLAY GAM 'Sand' PHITOP [PHIBOT]

b(2) Contents for clay layer

LN ELLAY GAM 'Clay' CTOP E50TOP [CBOT E50BOT]

b(3) Definitions

ELLAY = Elevation (ft) at top of layer

GAM = Saturated unit weight (pcf) of layer

'Sand' = Keyword

'Clay' = Keyword

PHITOP = Angle of internal friction (deg) at top of layer

[PHIBOT] = Angle of internal friction (deg) at bottom of layer; set equal to PHITOP if omitted

CTOP = Cohesion (psf) at top of layer

E50TOP = Strain at 50 percent of ultimate strength for clay at top of layer

CBOT = Cohesion (psf) at bottom of layer; set equal to CTOP if omitted

E50BOT = Strain at 50 percent of ultimate strength for clay at bottom of layer; set equal to E50TOP if omitted

b(4) Discussion and restrictions

(a) The soil profile is assumed to be composed of one (1) to fifteen (15) horizontal layers.

(b) Layers must be described in succession downward starting with the topmost layer. The last layer input is assumed to extend ad infinitum downward. The elevation of the top layer must be at or below the elevation at the pile head.

(c) Layers are assumed to be either sand (cohesionless) or clay (cohesive). Side friction force-displacement characteristics are assumed to vary linearly within each layer according to the soil properties provided at the top and bottom of each layer.

c. Data Lines if 'keyword' = 'Curve'--Minimum of three (3) lines

c(1) Line 1

(a) Contents

LN ELCURV NPTS [FMUL]

(b) Definitions

ELCURV = Elevation (ft) at side friction force-displacement curve

NPTS = Number of side friction force-displacement coordinates provided for this curve

[FMUL] = Multiplier for curve friction coordinate values; set equal to 1.0 if omitted

c(2) Line 2

(a) Contents

LN DISP(1) DISP(2) . . . DISP(NPTS)

(b) Definition

DISP(I) = Displacement coordinate (in.) of Ith point on side friction force-displacement curve

c(3) Line 3

(a) Contents

LN FRICT(1) FRICT(2) . . . FRICT(NPTS)

(b) Definition

FRICT(I) = Unit side friction coordinate (psf) of Ith point on side friction force-displacement curve

c(4) Discussion and restrictions

(a) A minimum of three data lines are required to describe a side friction force-displacement curve.

(b) Up to twenty-one (21) curves may be provided.

(c) The elevation of the first curve must be at or below the elevation at the pile head.

(d) If only one curve is provided, that curve is applied to all points on the pile at or below ELCURV.

(e) Curve elevations must proceed sequentially downward.

(f) Side friction force-displacement effects at intermediate points are obtained by linear interpolation between successive curves.

(g) Curve data described at elevations below the elevation at the pile tip are ignored.

(h) A minimum of two (2) displacement (DISP) and two (2) friction (FRICT) coordinates are required for each curve. A maximum of eight (8) coordinates are permitted for each curve.

(i) Displacement and friction coordinates must all be positive.

(j) Displacement coordinates must proceed from smallest to largest. Dual displacement values are not permitted.

(k) All side friction coordinate values for each curve are multiplied by FMUL.

41. Pile Tip Data--Zero (0), one (1), or three (3) lines. Entire section may be omitted:

a. Header--One (1) line

a(1) Contents

[LN 'Tip' 'keyword' [TIPA] [NPTS FMUL]]

a(2) Definitions

'Tip' = Data section title

'keyword' = 'Soil' if pile tip force-displacement behavior to be obtained from previously provided soil layer data

= 'Curve' if pile tip force-displacement curve follows

[TIPA] = Effective pile tip reaction area if 'keyword' = 'Soil'; omit if 'keyword' = 'Curve'

[NPTS] = Number of tip force-displacement coordinates provided; omit if 'keyword' = 'Soil'

[FMUL] = Multiplier for tip force coordinate values; omit if 'keyword' = 'Soil'; set equal to 1.0 if omitted for 'keyword' = 'Curve'

b. Line 2--One (1) line if 'keyword' = 'Curve'; omit if 'keyword' = 'Soil'

b(1) Contents

LN DISP(1) DISP(2) . . . DISP(NPTS)

b(2) Definition

DISP(I) = Displacement coordinate (in.) of Ith point on tip force-displacement curve

c. Line 3--One (1) line if 'keyword' = 'Curves'; omit if 'keyword' = 'Soil'

c(1) Contents

LN FORCE(1) FORCE(2) . . . FORCE(NPTS)

c(2) Definition

FORCE(I) = Tip force coordinate (lb) of Ith point on tip force-displacement curve

d. Discussion and restrictions

d(1) Effective tip reaction area must be greater than zero for 'keyword' = 'Soil'

d(2) A tip force-displacement curve is required if side friction curves are used.

d(3) A minimum of two (2) tip displacement (DISP) and two (2) tip force (FORCE) coordinates are required. A maximum of eight (8) coordinates are permitted.

d(4) Displacement and force coordinates must all be positive.

d(5) Displacement coordinates must proceed from smallest to largest. Dual displacement values are not permitted.

d(6) All tip force coordinate values are multiplied by FMUL.

42. Termination--One (1) line:

LN 'Finish'

Abbreviated Input Guide

43. Data items enclosed in brackets [ ] may be omitted. Braces { } indicate choose one.

44. Heading--One (1) to four (4) lines:

LN 'heading'

[LN 'heading']

[LN 'heading']

[LN 'heading']

45. Pile Cross-Section Properties--One (1) to twenty-one (21) lines:

a. Line 1

LN 'Pile' EL1 EL2 E OD A

b. Lines 2 to 21

[LN EL1 EL2 E OD A]

46. Side Friction Data--Minimum of two (2) lines:

a. Header--One (1) line

$$\text{LN 'Side'} \left\{ \begin{array}{l} \text{'Soil' [GAMWAT ELWAT]} \\ \text{'Curves'} \end{array} \right\}$$

b. Data lines for 'Soil'--One (1) to fifteen (15) lines

$$\text{LN ELLAY GAM} \left\{ \begin{array}{l} \text{'Sand' PHITOP [PHIBOT]} \\ \text{'Clay' CTOP E50TOP [CBOT E50BOT]} \end{array} \right\}$$

c. Data lines for 'Curves'--Minimum of three (3) lines, maximum of sixty-three (63) lines

c(1) Line 1

LN ELCURV NPTS [FMUL]

c(2) Line 2

LN DISP(1) DISP(2) . . . DISP(NPTS)

c(3) Line 3

LN FRICT(1) FRICT(2) . . . FRICT(NPTS)

47. Pile Tip Data--Zero (0), one (1) or three (3) lines:

a. Header--One (1) line

$$\text{[LN 'Tip'} \left\{ \begin{array}{l} \text{'Soil' TIPA} \\ \text{'Curve' NPTS [FMUL]} \end{array} \right\}$$

b. Line 2--Omit if 'Soil'

LN DISP(1) DISP(2) . . . DISP(NPTS)

c. Line 3--Omit if 'Soil'

LN FORCE(1) FORCE(2) . . . FORCE(NPTS)

48. Termination--One (1) line:

LN 'Finish'

PART VI: EXAMPLE SOLUTIONS

Example 1--Pile in Clay, Side Friction Curves Input

49. Reference 4 reports field test results and analytical results for a pile driven in clay ("Australia Test," References 3 and 4). The system characteristics are as follows:

a. Pile: Steel, rectangular (4 by 6 in.)

equivalent diameter	=	6.366 in.
area of steel	=	2.49 sq in.
E	=	30×10^6 psi
embedded length	=	80 ft

b. Soil: Clay, adjusted cohesion

at surface	=	300 psf
at 80 ft	=	612 psf

50. Numerical approximations of curves A, B, and C given in Reference 4 (see Figure 2) were used for side friction force-displacement characteristics. No tip reaction was present in the analysis reported in Reference 4. The input data file for example 1 appears as follows:

```
1000 'PILE IN CLAY, SIDE FRICTION CURVES INPUT, NO TIP REACTION
1010 'AUSTRALIA TEST' PILE FROM REESE AND COYLE
1020 'SIDE FRICTION CURVE DATA FROM COYLE
1030 PILE 0 -80 30.E6 6.366 2.49
1040 SIDE CURVES
1050 (CURVE 'A' FROM EL 0 TO EL -10)
1060 0 6 300
1070 0 0.05 0.1 0.15 0.175 0.2
1080 0 0.24 0.4 0.5  0.52  0.52
1090 -10 6 339
1100 0 0.05 0.1 0.15 0.175 0.2
1110 0 0.24 0.4 0.5  0.52  0.52
1120 (CURVE 'B' FROM EL -10 TO EL -20)
1130 -10 6 339
1140 0 0.05 0.1  0.15 0.175 0.2
1150 0 0.38 0.64 0.8  0.85  0.85
1160 -20 6 378
1170 0 0.05 0.1  0.15 0.175 0.2
1180 0 0.38 0.64 0.8  0.85  0.85
1190 (CURVE 'C' FROM EL -20 TO EL -80)
1200 -20 6 378
1210 0 0.05 0.07 0.1  0.135 0.2
1220 0 0.9  1.0  0.95 0.85  0.85
1230 -80 6 612
1240 0 0.05 0.07 0.1  0.135 0.2
1250 0 0.9  1.0  0.95 0.85  0.85
1260 FINISH
```

The interactive execution sequence for example 1 appears as follows:

```
     PROGRAM AXPILE - SOIL-STRUCTURE INTERACTION ANALYSIS
     OF AXIALLY LOADED PILES
     DATE: 06/16/83                        TIME: 11:20:50

     ARE INPUT DATA TO BE READ FROM TERMINAL OR FILE?
     ENTER 'TERMINAL' OR 'FILE'.
I>F
     ENTER INPUT FILE NAME (6 CHARACTERS MAXIMUM).
I>AXP1
     INPUT COMPLETE.
     DO YOU WANT INPUT DATA ECHOPRINTED TO YOUR
     TERMINAL, TO A FILE, TO BOTH OR NEITHER?
     ENTER 'TERMINAL', 'FILE', 'BOTH', OR 'NEITHER'.
I>F
     ENTER OUTPUT FILE NAME (6 CHARACTER MAXIMUM).
I>AXP1O
     DO YOU WANT TO EDIT INPUT DATA?  ENTER 'YES' OR 'NO'.
I>N
     INPUT COMPLETE.
     DO YOU WANT TO CONTINUE?  ENTER 'YES' OR 'NO'.
I>Y
     DO YOU WANT RESULTS WRITTEN TO YOUR TERMINAL, TO FILE 'AXP1O ', OR BOTH?
     ENTER 'TERMINAL', 'FILE', OR 'BOTH'.
I>F


     DO YOU WANT A LISTING OF NONLINEAR CURVES USED
     FOR SIDE FRICTION AND TIP RESISTANCE?  ENTER 'YES' OR 'NO'.
I>Y
     DO YOU WANT TO PLOT SIDE FRICTION CURVES?
     ENTER 'YES' OR 'NO'.
I>Y
     ENTER 'SINGLE' TO PLOT SIDE FRICTION CURVES ONE AT A TIME,
     ENTER 'ALL' TO PLOT ALL SIDE FRICTION CURVES ON ONE PAGE,
     OR 'FINISH'.
I>SINGLE
     ENTER ELEVATION BETWEEN      0.00 (FT) AND   -80.00 (FT)
     FOR CURVE TO BE PLOTTED.
I>-10.00
```

```
'PILE IN CLAY, SIDE FRICTION CURVES INPUT, NO TIP REACTION
'AUSTRAILIA TEST' PILE FROM REESE AND COYLE
'SIDE FRICTION CURVE DATA FROM COYLE
DATE: 06/16/83        TIME: 08:48:01

SIDE FRICTION CURVES FOR EL = -10. (FT)
```

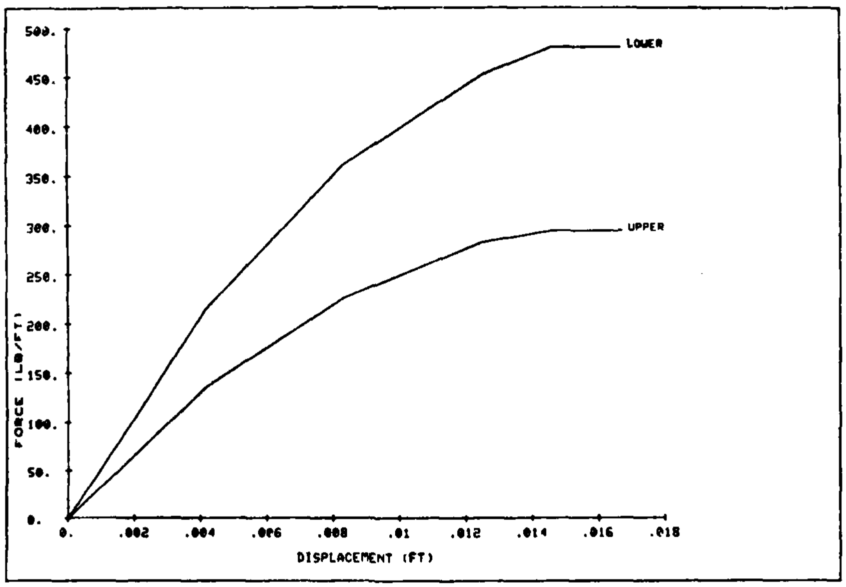

Figure 9. Plots of side friction curves, example 1
(Sheet 1 of 3)

```
     ENTER 'SINGLE' TO PLOT SIDE FRICTION CURVES ONE AT A TIME,
     ENTER 'ALL' TO PLOT ALL SIDE FRICTION CURVES ON ONE PAGE,
     OR 'FINISH'.
I>SINGLE
     ENTER ELEVATION BETWEEN     0.00 (FT) AND   -80.00 (FT)
     FOR CURVE TO BE PLOTTED.
I>-15.00
```

```
'PILE IN CLAY, SIDE FRICTION CURVES INPUT, NO TIP REACTION
'AUSTRAILIA TEST' PILE FROM REESE AND COYLE
'SIDE FRICTION CURVE DATA FROM COYLE
DATE: 06/16/83        TIME: 08:49:13

SIDE FRICTION CURVE FOR EL = -15. (FT)
INTERPOLATED FROM CURVES AT EL = -10. (FT) AND EL = -20. (FT)
```

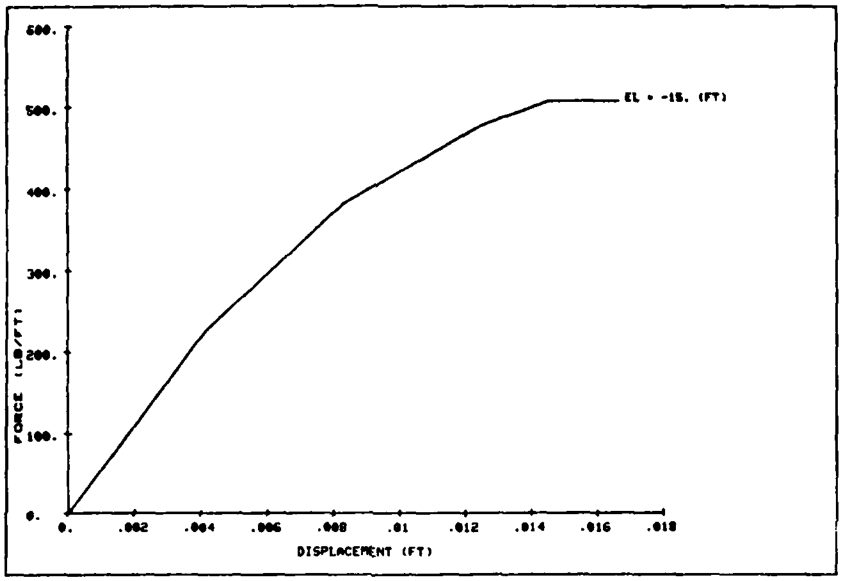

Figure 9. (Sheet 2 of 3)

```
     ENTER 'SINGLE' TO PLOT SIDE FRICTION CURVES ONE AT A TIME,
     ENTER 'ALL' TO PLOT ALL SIDE FRICTION CURVES ON ONE PAGE,
     OR 'FINISH'.
I>ALL
```

'PILE IN CLAY, SIDE FRICTION CURVES INPUT, NO TIP REACTION
'AUSTRAILIA TEST' PILE FROM REESE AND COYLE
SIDE FRICTION CURVE DATA FROM COYLE
DATE: 06/16/83   TIME: 08:49:55

ALL SIDE FRICTION CURVES

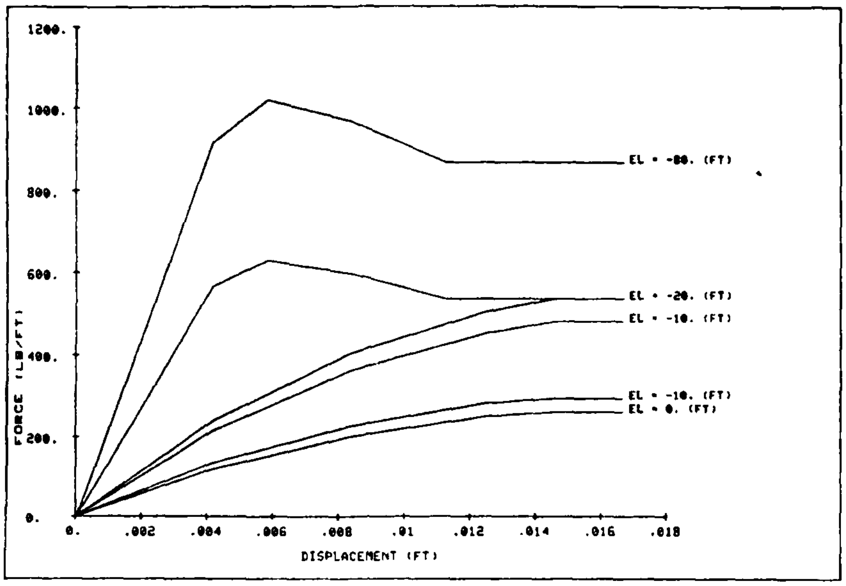

Figure 9. (Sheet 3 of 3)

```
     DO YOU WANT TO CONTINUE SOLUTION?  ENTER 'YES' OR 'NO'.
I>Y

     DO YOU WANT TO PLOT HEAD AND TIP RESULTS
     ENTER 'YES' OR 'NO'
I>Y
```

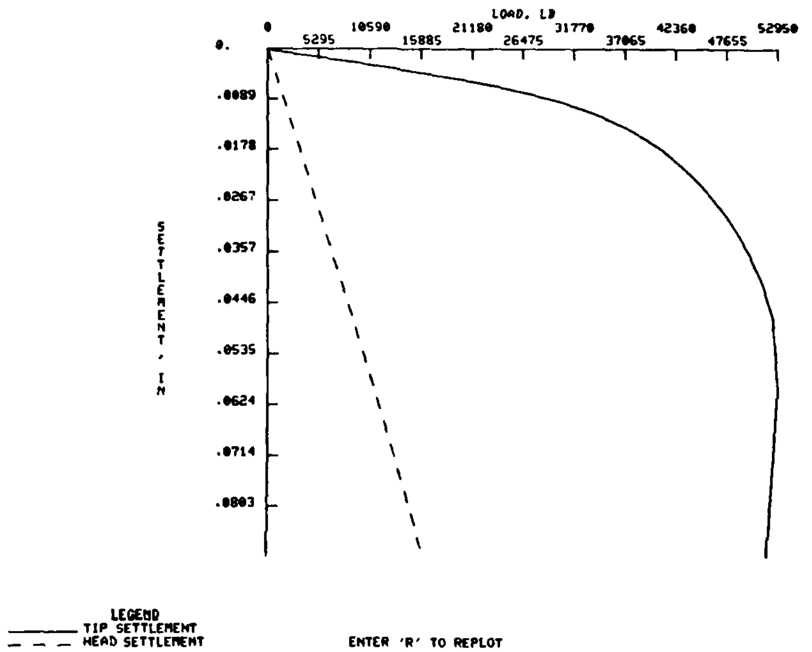

Figure 10. Plots of head and tip settlement, example 1

```
    DO YOU WANT COMPLETE RESULTS OUTPUT?  ENTER 'YES' OR 'NO'.
I>Y
    ENTER PILE HEAD DISPLACEMENT (INCHES): 0.0 .LE. DISP .LE.  .480
    FOR WHICH COMPLETE RESULTS ARE DESIRED.
I>.44

    DO YOU WANT TO PLOT COMPLETE RESULTS
    ENTER 'YES' OR 'NO'
I>Y
```

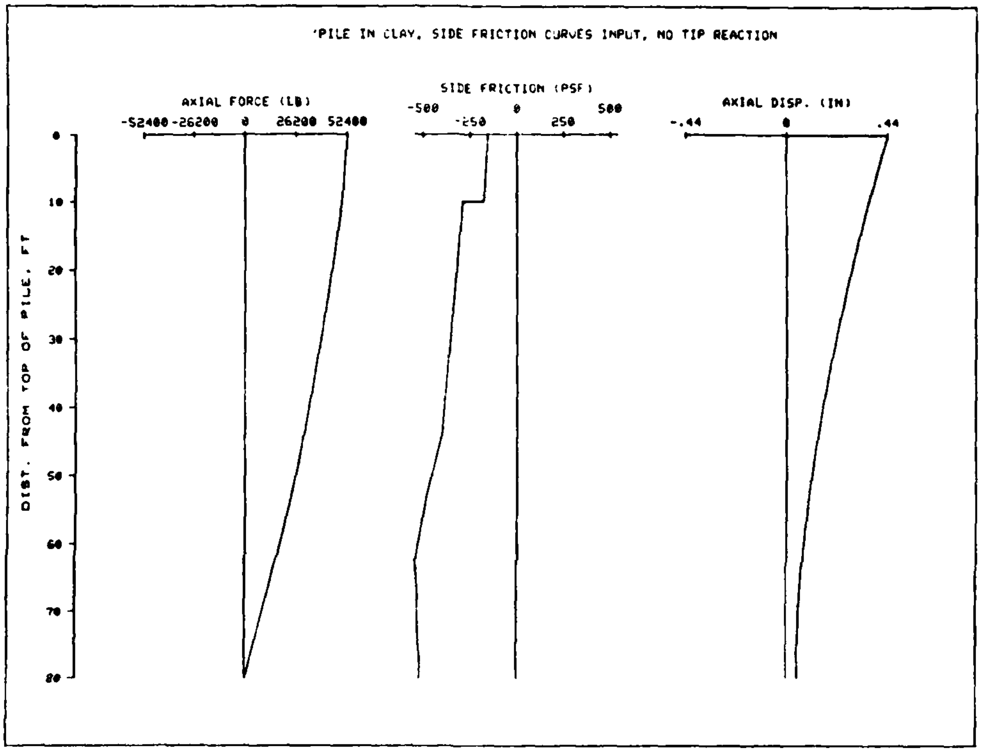

Figure 11. Plots of axial force, side friction, and axial displacement, example 1 (Sheet 1 of 2)

```
     DO YOU WANT COMPLETE RESULTS FOR ANOTHER DISPLACEMENT?
     ENTER 'YES' OR 'NO'.
I>Y
     ENTER PILE HEAD DISPLACEMENT (INCHES): 0.0 .LE. DISP .LE.  .480
     FOR WHICH COMPLETE RESULTS ARE DESIRED.
I>.22

     DO YOU WANT TO PLOT COMPLETE RESULTS
     ENTER 'YES' OR 'NO'
I>Y
```

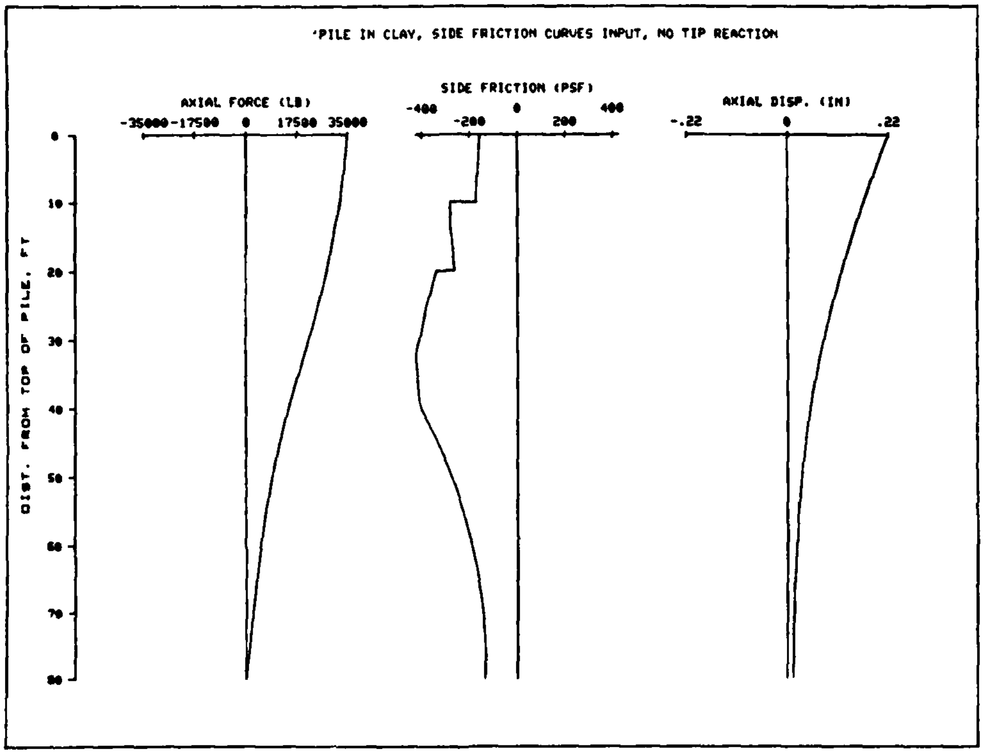

Figure 11. (Sheet 2 of 2)

```
     DO YOU WANT COMPLETE RESULTS FOR ANOTHER DISPLACEMENT?
     ENTER 'YES' OR 'NO'.
I>N
     OUTPUT COMPLETE.
     DO YOU WANT TO EDIT INPUT DATA FOR THE PROBLEM JUST COMPLETED?
     ENTER 'YES' OR 'NO'.
I>N
     DO YOU WANT TO MAKE ANOTHER 'AXPILE' RUN?  ENTER 'YES' OR 'NO'.
I>N
     ********** NORMAL TERMINATION **********
*
```

Figure 9 shows plots of the side friction curves; Figure 10 is a plot of head and tip settlement; and Figure 11 shows plots of axial force, side friction, and axial displacement.

39. Program output for example 1 is shown in the printouts on pages 38-41 and consists of the following:

- a. PART I: An echoprint (optional) of the input data (page 38).
- b. PART II: A listing (optional) of the nonlinear force-displacement curves generated by CAXPILE (page 39).
- c. PARTS III.A and III.B: A summary of results (page 40).
- d. PART III.C: Complete results (optional) for the user-specified pile head displacements (pages 40 and 41).

40. The following should be noted:

- a. When side friction or tip reaction curves are provided, all values are positive. The product of the force multiplier and curve force coordinates must produce unit side friction or unit tip reaction in pounds per square foot.
- b. When the program converts CAXPILE input data to nonlinear force-displacement curves, the unit friction or tip reaction multipliers are multiplied by the circumference of the pile and effective tip area to produce force per unit length (plf) or force (lb), respectively (see PART II.B, page 39). The signs of the curve force coordinates are changed to reflect that friction and tip reaction act to oppose pile displacements (positive downward).
- c. For this system, the number of curves generated by CAXPILE is the same as the number of input curves because the pile has constant effective outside diameter throughout its length. When a change in diameter occurs at a location where an input curve is not provided, CAXPILE generates two additional curves: one immediately above and one below the diameter change. The force-displacement coordinates for these additional curves are obtained from linear interpolation between the input curves bounding the point of diameter change.
- d. Although pile response is computed for pile head displacements at increments of 0.02 in., the summary lists values at increments of one-tenth of the displacement at which pile head force begins to decrease (PART III.B, page 40).

```
PROGRAM CAXPILE - SOIL-STRUCTURE INTERACTION ANALYSIS
OF AXIALLY LOADED PILES
DATE: 02/08/83                          TIME: 08:43:00

I.--INPUT DATA

1.--HEADING

  'PILE IN CLAY, SIDE FRICTION CURVES INPUT, NO TIP REACTION
  'AUSTRALIA TEST' PILE FROM REESE AND COYLE
  'SIDE FRICTION CURVE DATA FROM COYLE


2.--PILE DATA
     <--ELEVATION-->          MODULUS OF         OUTSIDE        SECTION
     START      STOP          ELASTICITY         DIAMETER         AREA
     (FT)       (FT)            (PSI)              (IN)           (IN)
     0.00     -80.00          3.00E+07             6.37           2.49


3.--SIDE FRICTION FORCE-DISPLACEMENT CURVE DATA

   CURVE ELEVATION =     0.00 (FT)      FRICTION MULTIPLIER =    300.00

     DISPL. COORD. (IN):     0.0000      .0500      .1000      .1500      .1750
                              .2000
     FORCE COORD. (PSF):       0.00        .24        .40        .50        .52
                                .52

   CURVE ELEVATION =  -10.00 (FT)      FRICTION MULTIPLIER =    339.00

     DISPL. COORD. (IN):     0.0000      .0500      .1000      .1500      .1750
                              .2000
     FORCE COORD. (PSF):       0.00        .24        .40        .50        .52
                                .52

   CURVE ELEVATION =  -10.00 (FT)      FRICTION MULTIPLIER =    339.00

     DISPL. COORD. (IN):     0.0000      .0500      .1000      .1500      .1750
                              .2000
     FORCE COORD. (PSF):       0.00        .38        .64        .80        .85
                                .85

   CURVE ELEVATION =  -20.00 (FT)      FRICTION MULTIPLIER =    378.00

     DISPL. COORD. (IN):     0.0000      .0500      .1000      .1500      .1750
                              .2000
     FORCE COORD. (PSF):       0.00        .38        .64        .80        .85
                                .85

   CURVE ELEVATION =  -20.00 (FT)      FRICTION MULTIPLIER =    378.00

     DISPL. COORD. (IN):     0.0000      .0500      .0700      .1000      .1350
                              .2000
     FORCE COORD. (PSF):       0.00        .90       1.00        .95        .85
                                .85

   CURVE ELEVATION =  -80.00 (FT)      FRICTION MULTIPLIER =    612.00

     DISPL. COORD. (IN):     0.0000      .0500      .0700      .1000      .1350
                              .2000
     FORCE COORD. (PSF):       0.00        .90       1.00        .95        .85
                                .85


4.--TIP FORCE-DISPLACEMENT DATA
     NONE
```

```
PROGRAM CAXPILE - SOIL-STRUCTURE INTERACTION ANALYSIS
OF AXIALLY LOADED PILES
DATE: 02/08/83                        TIME: 08:43:25

II.--NONLINEAR CURVE DATA GENERATED BY CAXPILE

II.A.--HEADING
  'PILE IN CLAY, SIDE FRICTION CURVES INPUT, NO TIP REACTION
  'AUSTRALIA TEST' PILE FROM REESE AND COYLE
  'SIDE FRICTION CURVE DATA FROM COYLE


II.B --NONLINEAR CURVES FOR SIDE FRICTION
     OBTAINED FROM INPUT CURVE DATA.

DISTRIBUTION   STARTS  AT ELEVATION     0.00 (FT)

               CURVE COORDINATES
          DISPL (FT)      FORCE (LBS/FT)
          0.               0.
          4.1667E-03      -1.2000E+02
          8.3333E-03      -1.9999E+02
          1.2500E-02      -2.4999E+02
          1.4583E-02      -2.5999E+02
          1.6667E-02      -2.5999E+02

DISTRIBUTION    ENDS   AT ELEVATION   -10.00 (FT)

               CURVE COORDINATES
          DISPL (FT)      FORCE (LBS/FT)
          0.               0.
          4.1667E-03      -1.3560E+02
          8.3333E-03      -2.2599E+02
          1.2500E-02      -2.8249E+02
          1.4583E-02      -2.9379E+02
          1.6667E-02      -2.9379E+02


DISTRIBUTION   STARTS  AT ELEVATION   -10.00 (FT)

               CURVE COORDINATES
          DISPL (FT)      FORCE (LBS/FT)
          0.               0.
          4.1667E-03      -2.1469E+02
          8.3333E-03      -3.6159E+02
          1.2500E-02      -4.5199E+02
          1.4583E-02      -4.8024E+02
          1.6667E-02      -4.8024E+02

DISTRIBUTION    ENDS   AT ELEVATION   -20.00 (FT)

               CURVE COORDINATES
          DISPL (FT)      FORCE (LBS/FT)
          0.               0.
          4.1667E-03      -2.3939E+02
          8.3333E-03      -4.0319E+02
          1.2500E-02      -5.0398E+02
          1.4583E-02      -5.3548E+02
          1.6667E-02      -5.3548E+02


DISTRIBUTION   STARTS  AT ELEVATION   -20.00 (FT)

               CURVE COORDINATES
          DISPL (FT)      FORCE (LBS/FT)
          0.               0.
          4.1667E-03      -5.6698E+02
          5.8333E-03      -6.2998E+02
          8.3333E-03      -5.9848E+02
          1.1250E-02      -5.3548E+02
          1.6667E-02      -5.3548E+02

DISTRIBUTION    ENDS   AT ELEVATION   -80.00 (FT)

               CURVE COORDINATES
          DISPL (FT)      FORCE (LBS/FT)
          0.               0.
          4.1667E-03      -9.1797E+02
          5.8333E-03      -1.0200E+03
          8.3333E-03      -9.6897E+02
          1.1250E-02      -8.6697E+02
          1.6667E-02      -8.6697E+02
```

PROGRAM CAXPILE - SOIL-STRUCTURE INTERACTION ANALYSIS
OF AXIALLY LOADED PILES
DATE: 02/08/83 TIME: 08:43:36

III.--SUMMARY OF RESULTS

III.A.--HEADING

'PILE IN CLAY, SIDE FRICTION CURVES INPUT, NO TIP REACTION
'AUSTRALIA TEST' PILE FROM REESE AND COYLE
'SIDE FRICTION CURVE DATA FROM COYLE

III.B.--DISPLACEMENTS AND FORCES

<--PILE HEAD-->		<--PILE TIP--->	
DISPL (IN)	FORCE (LB)	DISPL (IN)	FORCE (LB)
0.000	0.	0.000	0.
.046	8459.	.002	0.
.092	16665.	.004	0.
.138	24248.	.007	0.
.184	30782.	.010	0.
.230	36151.	.013	0.
.276	40596.	.018	0.
.322	44434.	.023	0.
.368	47893.	.030	0.
.414	50961.	.040	0.
.460	52957.	.059	0.
.480	51879.	.089	0.

MAXIMUM PILE HEAD FORCE = 52957. (LB)
AT DISPLACEMENT = .460 (IN)

III.C.--COMPLETE RESULTS FOR PILE HEAD DISPLACEMENT = .460 (IN)

ELEVATION (FT)	DISPLACEMENT (IN)	AXIAL FORCE (LB)	SIDE FRICTION (PSF)
0.00	.460	52957.	-156.00
-1.00	.452	52695.	-158.03
-2.00	.443	52430.	-160.06
-3.00	.435	52162.	-162.08
-4.00	.426	51890.	-164.11
-5.00	.418	51615.	-166.14
-6.00	.410	51336.	-168.17
-7.00	.402	51054.	-170.20
-8.00	.393	50769.	-172.22
-9.00	.385	50480.	-174.25
-10.00	.377	50188.	-176.28
-10.00	.377	50188.	-288.15
-11.00	.369	49705.	-291.47
-12.00	.361	49217.	-294.78
-13.00	.353	48723.	-298.10
-14.00	.345	48223.	-301.41
-15.00	.338	47718.	-304.73
-16.00	.330	47207.	-308.04
-17.00	.323	46691.	-311.36
-18.00	.315	46169.	-314.67
-19.00	.308	45642.	-317.99
-20.00	.300	45110.	-321.30
-21.00	.293	44571.	-324.62
-22.00	.286	44028.	-327.93
-23.00	.279	43478.	-331.25
-24.00	.272	42923.	-334.56
-25.00	.265	42363.	-337.88

(Continued)

-26.00	.259	41797.	-341.19
-27.00	.252	41226.	-344.51
-28.00	.245	40649.	-347.82
-29.00	.239	40066.	-351.14
-30.00	.232	39478.	-354.45
-31.00	.226	38885.	-357.77
-32.00	.220	38286.	-361.08
-33.00	.214	37681.	-364.40
-34.00	.208	37071.	-367.71
-35.00	.202	36456.	-371.03
-36.00	.196	35835.	-374.34
-37.00	.190	35208.	-377.66
-38.00	.185	34576.	-380.97
-39.00	.179	33938.	-384.29
-40.00	.174	33295.	-387.60
-41.00	.169	32646.	-390.92
-42.00	.163	31992.	-394.23
-43.00	.158	31332.	-397.55
-44.00	.153	30667.	-400.86
-45.00	.149	29996.	-404.17
-46.00	.144	29320.	-407.49
-47.00	.139	28638.	-410.80
-48.00	.135	27952.	-414.74
-49.00	.130	27252.	-424.28
-50.00	.126	26537.	-433.76
-51.00	.122	25807.	-443.17
-52.00	.118	25060.	-452.51
-53.00	.114	24298.	-461.76
-54.00	.110	23521.	-470.92
-55.00	.106	22729.	-479.97
-56.00	.102	21921.	-488.92
-57.00	.099	21099.	-497.10
-58.00	.096	20265.	-503.73
-59.00	.092	19420.	-510.28
-60.00	.089	18564.	-516.75
-61.00	.086	17698.	-523.13
-62.00	.084	16821.	-529.43
-63.00	.081	15933.	-535.63
-64.00	.079	15035.	-541.74
-65.00	.076	14128.	-547.75
-66.00	.074	13210.	-553.65
-67.00	.072	12282.	-559.43
-68.00	.070	11345.	-565.11
-69.00	.068	10402.	-564.40
-70.00	.067	9462.	-563.70
-71.00	.065	8523.	-563.37
-72.00	.064	7584.	-563.42
-73.00	.063	6645.	-563.86
-74.00	.062	5704.	-564.70
-75.00	.061	4762.	-565.96
-76.00	.060	3817.	-567.63
-77.00	.060	2869.	-569.73
-78.00	.059	1918.	-572.27
-79.00	.059	962.	-575.26
-80.00	.059	0.	-578.71

e. Complete output (PART III.C, pages 40 and 41 may be obtained for as many pile head displacements as desired. Any displacement may be specified for complete output up to the maximum displacement reported in the summary.

f. Two lines are printed for any elevation where an abrupt change in side friction occurs (see at elevation -10, page 40). Abrupt changes in side friction usually occur at soil layer boundaries, at the water elevation if it lies within a soil layer, at changes in effective outside diameter, or when two curves are input for the same elevation. Note that at elevation -20 (page 40) only a single line is printed, even though two curves were input for that elevation; both curves produce identical values of side friction for this case.

53. Results obtained by CAXPILE are compared with analytical results and field test results (References 3 and 4) in Figure 12. The

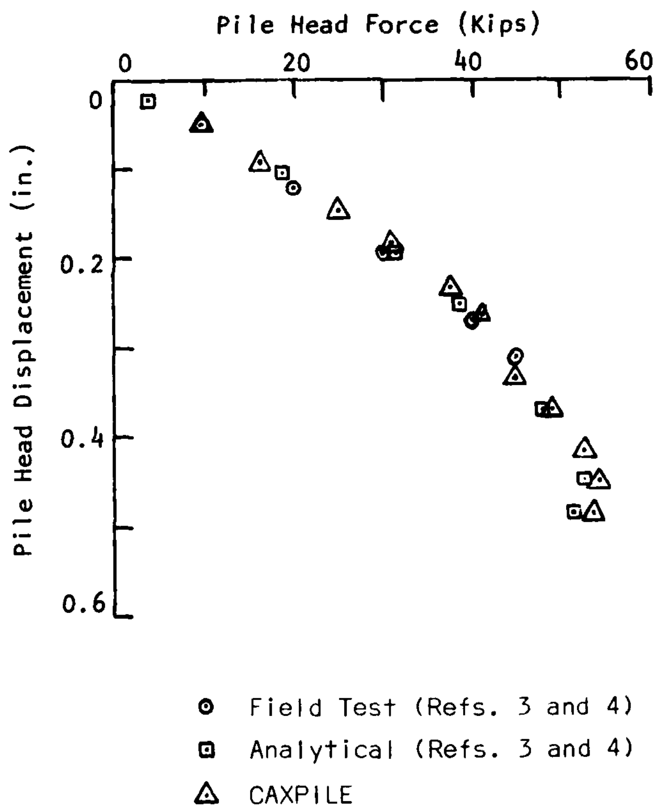

Figure 12. Comparison of results for example 1

differences between CAXPILE results and the analytical results from Reference 4 are probably attributable to treatment of side friction by a linear variation rather than as an average as used in Reference 4 and to a smaller increment in pile head displacement used in CAXPILE.

Example 2--Pile in Clay; Soil Data Input

54. The "Australia Test" pile-soil system described above was analyzed with side friction effects determined from soil properties. Nominal cohesions of 200 psf at the ground surface and 408 psf at elevation -80 were used in order to duplicate the adjusted cohesions of the preceding example. A value of $\varepsilon_{50} = 0.01$ was assumed for the clay. This property does not affect the solution since no tip reaction is present. The input data file for example 2 appears as follows:

```
1000 'PILE IN CLAY, SOIL DATA INPUT, NO TIP REACTION
1010 'AUSTRALIA TEST' PILE FROM REESE AND COYLE
1020 PILE 0 -80 30.E6 6.366 2.49
1030 SIDE SOIL
1040 0 112 CLAY 200 0.01 408 0.01
1050 FINISH
```

The echoprint from CAXPILE is shown on page 46.

55. Nonlinear side friction curves generated by CAXPILE are shown on page 46. The force multiplier for each curve is the product of adjusted cohesion and circumferential area per foot of pile. Displacement and force coordinates for each curve are those incorporated in CAXPILE for curves A, B, and C, respectively, in Figure 2.

56. The summary of results providing forces and displacements at the pile head and tip is given on page 48. The predicted response of the system is essentially identical with that of example 1 (Figure 13). Small differences are due to the slightly different shape of the load transfer curves used in the two examples.

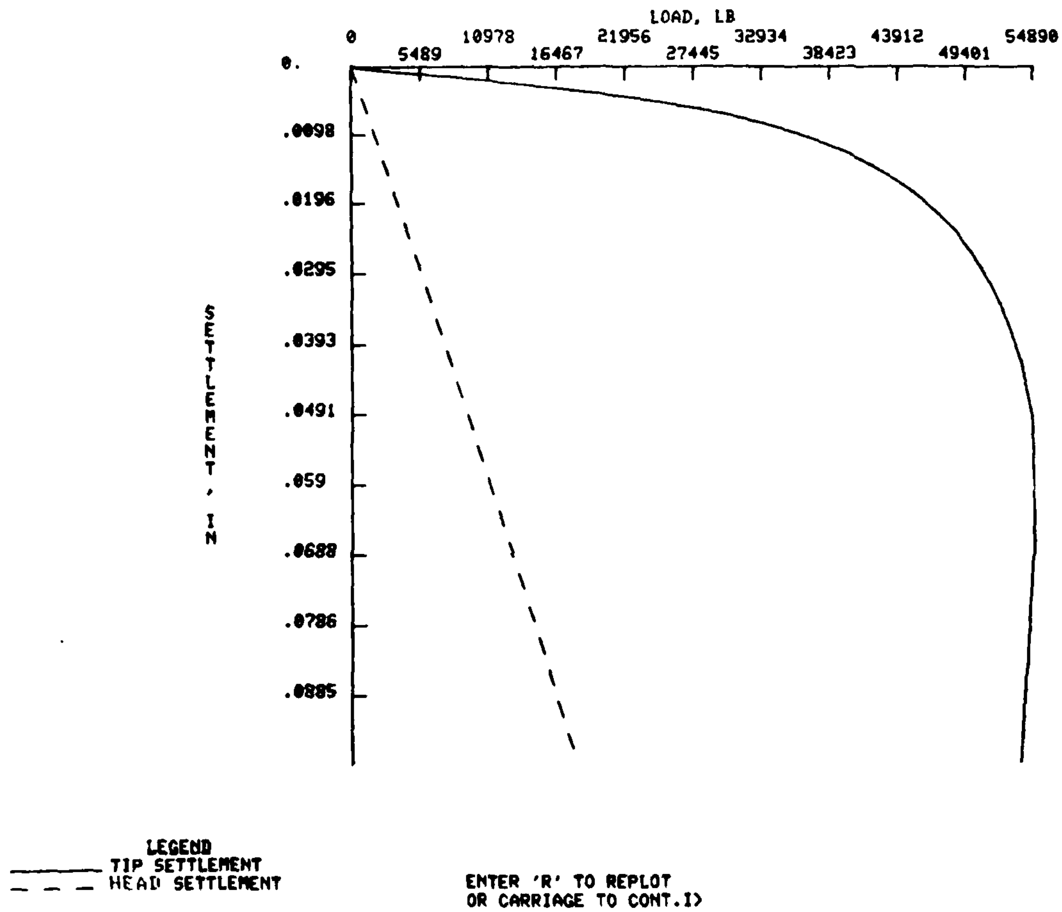

Figure 13. Plots of head and tip settlement, example 2

```
PROGRAM CAXPILE - SOIL-STRUCTURE INTERACTION ANALYSIS
OF AXIALLY LOADED PILES
DATE: 02/08/83                            TIME: 07:24:49

I.--INPUT DATA

1.--HEADING

  'PILE IN CLAY, SOIL DATA INPUT, NO TIP REACTION
  "AUSTRALIA TEST" PILE FROM REESE AND COYLE

2.--PILE DATA
     <--ELEVATION-->         MODULUS OF          OUTSIDE        SECTION
     START      STOP         ELASTICITY          DIAMETER         AREA
      (FT)      (FT)            (PSI)              (IN)           (IN)
      0.00     -80.00         3.00E+07             6.37           2.49

3.--SIDE FRICTION SOIL AND WATER DATA
          GROUND WATER UNIT WEIGHT =      0.0  (PCF)

  SOIL LAYER DATA
                            <-----TOP OF LAYER----->     <----BOTTOM OF LAYER--->
   TOP    UNIT              FRICT                STRAIN    FRICT                STRAIN
   EL.    WEIGHT            ANGLE     COH.     50% ULT.    ANGLE     COH.     50% ULT.
  (FT)     (PCF)            (DEG)     (PSF)                (DEG)     (PSF)
  0.00    112.00                       200.      .0100                408.      .0100

4.--TIP FORCE-DISPLACEMENT DATA
     NONE




PROGRAM CAXPILE - SOIL-STRUCTURE INTERACTION ANALYSIS
OF AXIALLY LOADED PILES
DATE: 02/08/83                            TIME: 07:25:12

II.--NONLINEAR CURVE DATA GENERATED BY CAXPILE

II.A.--HEADING
  'PILE IN CLAY, SOIL DATA INPUT, NO TIP REACTION
  "AUSTRALIA TEST" PILE FROM REESE AND COYLE



[illegible] CURVES FOR SIDE FRICTION
   [illegible] FROM SOIL DATA.

[illegible] STARTS AT ELEVATION     0.00 (FT)

            [illegible] COORDINATES
     [illegible]         FORCE [illegible]
       .                     0
     [illegible]E-03        -5.9998E+01
     [illegible].1250E-03     [illegible].4999E+01
     4.16[illegible]E-03      1.[illegible]E+02
     [illegible].5877E-03    -1.5000E+02
     [illegible].7167E-03    -1.7999E+02
     [illegible]E-03         -1.9999E+02
     1.0417E-02             -2.[illegible]E+02
     1.2500E-02             -2.4999E+02
     1.45[illegible]E-02      2.5999E+02
     1.6667E-02             -2.6499E+02
     1.8750E-02              [illegible].6999E+02
     2.0833E-02              [illegible].7499E+02
```

DISTRIBUTION ENDS AT ELEVATION -10.00 (FT)

CURVE COORDINATES

DISPL (FT)	FORCE (LBS/FT)
0.	0.
2.0833E-03	-6.7798E+01
3.1250E-03	-9.6047E+01
4.1667E-03	-1.2995E+02
5.5833E-03	-1.6949E+02
6.9167E-03	-2.0339E+02
8.3333E-03	-2.2599E+02
1.0417E-02	-2.5989E+02
1.2500E-02	-2.8249E+02
1.4583E-02	-2.9379E+02
1.6667E-02	-2.9944E+02
1.8750E-02	-3.0509E+02
2.0833E-02	-3.1074E+02

DISTRIBUTION STARTS AT ELEVATION -10.00 (FT)

CURVE COORDINATES

DISPL (FT)	FORCE (LBS/FT)
0.	0.
2.0833E-03	-9.6047E+01
3.1250E-03	-1.4125E+02
4.1667E-03	-1.9209E+02
5.5833E-03	-2.4294E+02
6.9167E-03	-2.9379E+02
8.3333E-03	-3.3899E+02
1.0417E-02	-4.0114E+02
1.2500E-02	-4.4634E+02
1.4583E-02	-4.7459E+02
1.6667E-02	-4.8588E+02
1.8750E-02	-4.9718E+02
2.0833E-02	-5.0283E+02

DISTRIBUTION ENDS AT ELEVATION -20.00 (FT)

CURVE COORDINATES

DISPL (FT)	FORCE (LBS/FT)
0.	0.
2.0833E-03	-1.0710E+02
3.1250E-03	-1.5750E+02
4.1667E-03	-2.1419E+02
5.5833E-03	-2.7089E+02
6.9167E-03	-3.2759E+02
8.3333E-03	-3.7799E+02
1.0417E-02	-4.4729E+02
1.2500E-02	-4.9768E+02
1.4583E-02	-5.2918E+02
1.6667E-02	-5.4178E+02
1.8750E-02	-5.5438E+02
2.0833E-02	-5.6068E+02

DISTRIBUTION STARTS AT ELEVATION -20.00 (FT)

CURVE COORDINATES

DISPL (FT)	FORCE (LBS/FT)
0.	0.
2.0833E-03	-3.4649E+02
3.1250E-03	-4.7879E+02
4.1667E-03	-5.8588E+02
5.5833E-03	-6.2998E+02
6.9167E-03	-6.1738E+02
8.3333E-03	-5.9848E+02
1.0417E-02	-5.8588E+02
1.2500E-02	-5.7958E+02
1.4583E-02	-5.7328E+02
1.6667E-02	-5.6698E+02
1.8750E-02	-5.6698E+02
2.0833E-02	-5.6698E+02

DISTRIBUTION ENDS AT ELEVATION -80.00 (FT)

CURVE COORDINATES

DISPL (FT)	FORCE (LBS/FT)
0.	0.
2.0833E-03	-5.6098E+02
3.1250E-03	-7.7518E+02
4.1667E-03	-9.4857E+02
5.5833E-03	-1.0200E+03
6.9167E-03	-9.9957E+02
8.3333E-03	-9.6897E+02
1.0417E-02	-9.4857E+02
1.2500E-02	-9.3837E+02
1.4583E-02	-9.2817E+02
1.6667E-02	-9.1797E+02
1.8750E-02	-9.1797E+02
2.0833E-02	-9.1797E+02

PROGRAM CAXPILE - SOIL-STRUCTURE INTERACTION ANALYSIS
OF AXIALLY LOADED PILES
DATE: 02/08/83 TIME: 07:25:20

III.--SUMMARY OF RESULTS

III.A.--HEADING

'PILE IN CLAY, SOIL DATA INPUT, NO TIP REACTION
'AUSTRALIA TEST' PILE FROM REESE AND COYLE

III.B.--DISPLACEMENTS AND FORCES

<--PILE HEAD-->		<--PILE TIP--->	
DISPL (IN)	FORCE (LB)	DISPL (IN)	FORCE (LB)
0.000	0.	0.000	0.
.048	9015.	.002	0.
.096	17729.	.003	0.
.144	25508.	.005	0.
.192	32137.	.008	0.
.240	37716.	.011	0.
.288	42503.	.015	0.
.336	46667.	.020	0.
.384	50311.	.028	0.
.432	53410.	.039	0.
.480	54897.	.067	0.
.500	53870.	.098	0.

MAXIMUM PILE HEAD FORCE = 54897. (LB)
AT DISPLACEMENT = .480 (IN)

Example 3--Pile in Clay; Soil Data Input, Tip Reaction Added

57. The input data for example 2 were edited during execution to add a reaction determined from soil properties at the pile tip. The input file saved by CAXPILE following editing appears as follows:

```
1000 'AUSTRALIA TEST' SYSTEM FROM EXAMPLE 2
1010 WITH TIP REACTION FROM SOIL DATA ADDED
1020 PILE  0.00  -80.0  3.00E7  6.366  2.49
1030 SIDE SOIL
1040   0.00   112.00  CLAY  200.0  0.01  408.0  0.01
1050 TIP SOIL
1060 FINISH
```

The echoprint is shown on page 50.

58. Nonlinear curves generated by CAXPILE are shown on page 50. Curves for side friction are identical with those of the previous example. The force-displacement curve for tip reaction is shown on page 52.

59. The summary of results for this example is shown on page 52. The contribution of tip reaction to pile capacity is small in this case (Figure 14). It is of interest to note that maximum pile capacity is reached before maximum tip reaction occurs.

PROGRAM CAXPILE - SOIL-STRUCTURE INTERACTION ANALYSIS
OF AXIALLY LOADED PILES
DATE: 02/09/83   TIME: 09:22:14

I.--INPUT DATA

1.--HEADING

'AUSTRALIA TEST' SYSTEM FROM EXAMPLE 2
WITH TIP REACTION FROM SOIL DATA ADDED

2.--PILE DATA

<--ELEVATION--> START (FT)	STOP (FT)	MODULUS OF ELASTICITY (PSI)	OUTSIDE DIAMETER (IN)	SECTION AREA (IN)
0.00	-80.00	3.00E+07	6.37	2.49

3.--SIDE FRICTION SOIL AND WATER DATA
GROUND WATER UNIT WEIGHT =   0.0 (PCF)

SOIL LAYER DATA

		<-----TOP OF LAYER----->			<----BOTTOM OF LAYER--->		
TOP EL. (FT)	UNIT WEIGHT (PCF)	FRICT ANGLE (DEG)	COH. (PSF)	STRAIN 50% ULT.	FRICT ANGLE (DEG)	COH. (PSF)	STRAIN 50% ULT.
0.00	112.00		200.	.0100		408.	.0100

4.--TIP FORCE-DISPLACEMENT DATA

FROM SOIL DATA AT PILE TIP ELEVATION =   -80.00 (FT)
EFFECTIVE TIP AREA   =   31.83 (SQIN)

PROGRAM CAXPILE - SOIL-STRUCTURE INTERACTION ANALYSIS
OF AXIALLY LOADED PILES
DATE: 02/09/83   TIME: 09:22:33

II.--NONLINEAR CURVE DATA GENERATED BY CAXPILE

II.A.--HEADING
'AUSTRALIA TEST' SYSTEM FROM EXAMPLE 2
WITH TIP REACTION FROM SOIL DATA ADDED

II.B.--NONLINEAR CURVES FOR SIDE FRICTION
OBTAINED FROM SOIL DATA

DISTRIBUTION   STARTS AT ELEVATION   0.00 (FT)

CURVE COORDINATES

DISPL (FT)	FORCE (LBS/FT)
	0.
2.0833E-03	-5.9998E+01
3.1250E-03	-8.4997E+01
4.1667E-03	-1.1500E+02
5.5833E-03	-1.5000E+02
6.9167E-03	-1.7999E+02
8.3333E-03	-1.9999E+02
1.0417E-02	-2.2999E+02
1.2500E-02	-2.4999E+02
1.4583E-02	-2.5999E+02
1.6667E-02	-2.6499E+02
1.8750E-02	-2.6999E+02
2.0833E-02	-2.7499E+02

DISTRIBUTION ENDS AT ELEVATION -10.00 (FT)

CURVE COORDINATES

DISPL (FT)	FORCE (LBS/FT)
0.	0.
2.0833E-03	-6.7798E+01
3.1250E-03	-9.6047E+01
4.1667E-03	-1.2995E+02
5.5833E-03	-1.6949E+02
6.9167E-03	-2.0339E+02
8.3333E-03	-2.2599E+02
1.0417E-02	-2.5789E+02
1.2500E-02	-2.8249E+02
1.4583E-02	-2.9379E+02
1.6667E-02	-2.9944E+02
1.8750E-02	-3.0509E+02
2.0833E-02	-3.1074E+02

DISTRIBUTION STARTS AT ELEVATION -10.00 (FT)

CURVE COORDINATES

DISPL (FT)	FORCE (LBS/FT)
0.	0.
2.0833E-03	-9.6047E+01
3.1250E-03	-1.4125E+02
4.1667E-03	-1.9209E+02
5.5833E-03	-2.4294E+02
6.9167E-03	-2.9379E+02
8.3333E-03	-3.3899E+02
1.0417E-02	-4.0114E+02
1.2500E-02	-4.4634E+02
1.4583E-02	-4.7459E+02
1.6667E-02	-4.8588E+02
1.8750E-02	-4.9718E+02
2.0833E-02	-5.0283E+02

DISTRIBUTION ENDS AT ELEVATION -20.00 (FT)

CURVE COORDINATES

DISPL (FT)	FORCE (LBS/FT)
0.	0.
2.0833E-03	-1.0710E+02
3.1250E-03	-1.5750E+02
4.1667E-03	-2.1419E+02
5.5833E-03	-2.7089E+02
6.9167E-03	-3.2759E+02
8.3333E-03	-3.7799E+02
1.0417E-02	-4.4729E+02
1.2500E-02	-4.9768E+02
1.4583E-02	-5.2918E+02
1.6667E-02	-5.4178E+02
1.8750E-02	-5.5438E+02
2.0833E-02	-5.6068E+02

DISTRIBUTION STARTS AT ELEVATION -20.00 (FT)

CURVE COORDINATES

DISPL (FT)	FORCE (LBS/FT)
0.	0.
2.0833E-03	-3.4649E+02
3.1250E-03	-4.7879E+02
4.1667E-03	-5.8588E+02
5.5833E-03	-6.2998E+02
6.9167E-03	-6.1738E+02
8.3333E-03	-5.9848E+02
1.0417E-02	-5.8588E+02
1.2500E-02	-5.7958E+02
1.4583E-02	-5.7328E+02
1.6667E-02	-5.6698E+02
1.8750E-02	-5.6698E+02
2.0833E-02	-5.6698E+02

DISTRIBUTION ENDS AT ELEVATION -80.00 (FT)

CURVE COORDINATES

DISPL (FT)	FORCE (LBS/FT)
0.	0.
2.0833E-03	-5.6098E+02
3.1250E-03	-7.7518E+02
4.1667E-03	-9.4857E+02
5.5833E-03	-1.0200E+03
6.9167E-03	-9.9957E+02
8.3333E-03	-9.6897E+02
1.0417E-02	-9.4857E+02
1.2500E-02	-9.3837E+02
1.4583E-02	-9.2817E+02
1.6667E-02	-9.1797E+02
1.8750E-02	-9.1797E+02
2.0833E-02	-9.1797E+02

II.L. NONLINEAR CURVE FOR PILE TIP RESISTANCE
OBTAINED FROM SOIL DATA.

CURVE COORDINATES

DISPL (FT)	FORCE (LB)
.	.
1.0610E-02	1.2[illegible]E+03

PROGRAM CAXPILE - SOIL-STRUCTURE INTERACTION ANALYSIS
OF AXIALLY LOADED PILES
DATE: 02/09/83 TIME: 09:22:45

III.--SUMMARY OF RESULTS

III.A.--HEADING

'AUSTRALIA TEST' SYSTEM FROM EXAMPLE 2
WITH TIP REACTION FROM SOIL DATA ADDED

III.B.--DISPLACEMENTS AND FORCES

<--PILE HEAD-->		<--PILE TIP--->	
DISPL (IN)	FORCE (LB)	DISPL (IN)	FORCE (LB)
0.000	0.	0.000	0.
.048	9015.	.002	15.
.096	17731.	.003	31.
.144	25510.	.005	49.
.192	32141.	.008	72.
.240	37724.	.011	101.
.288	42516.	.015	139.
.336	46691.	.020	189.
.384	50361.	.027	259.
.432	53512.	.038	362.
.480	55487.	.060	575.
.500	55069.	.084	800.

MAXIMUM PILE HEAD FORCE = 55487. (LB)
AT DISPLACEMENT = .480 (IN)

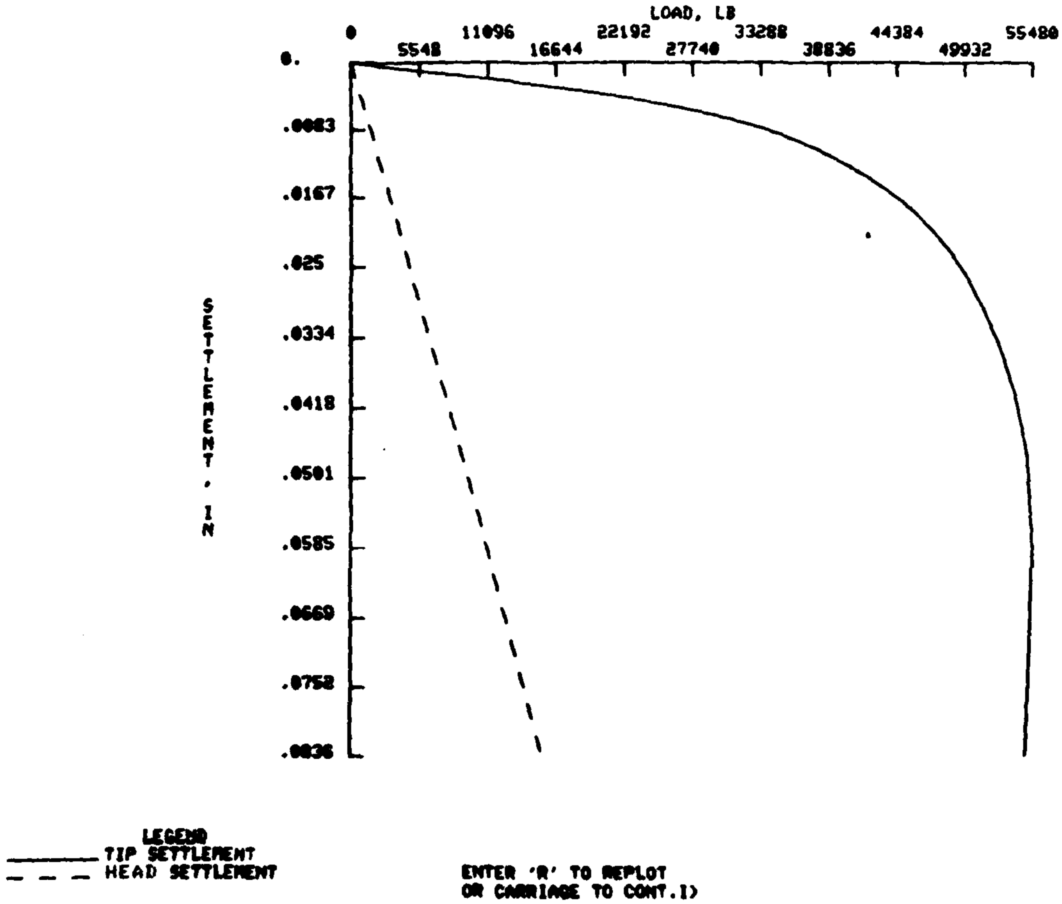

Figure 14. Plots of head and tip settlement, example 3

Example 4--Pile in Layered Soil

60. The pile-soil system shown in Figure 15 was analyzed with side friction and tip reaction determined from soil properties. The input file appears as follows:

```
1000 HP 14X89 PILE IN LAYERED SOIL
1010 'TIP REACTION FROM SOIL DATA
1020 PILE 0 -105.5 30.E6 18.16 26.1
1030 SIDE SOIL
1040 0 105 CLAY 750 .01
1050 -27 130 SAND 30
1060 TIP SOIL 204
1070 FINISH
```

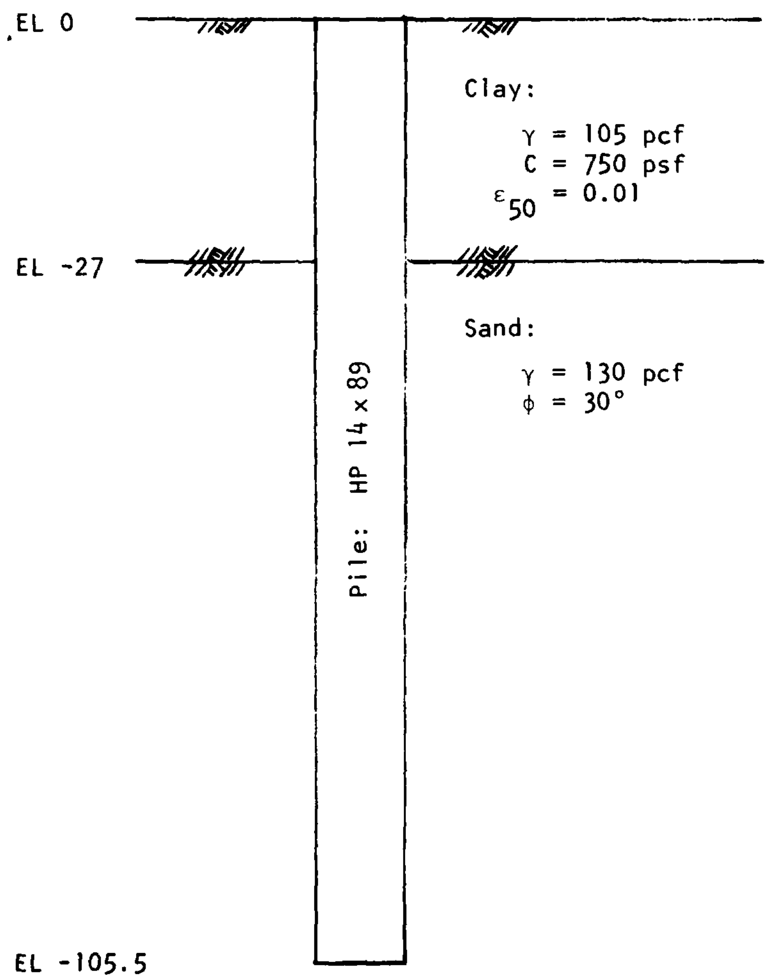

Figure 15. Pile-soil system for example 4

The echoprint of input data is shown on page 56.

61. The nonlinear curve data generated by CAXPILE are shown on pages 56-60. The first six side friction curves (pages 57 and 58) are for the three zones (A, B, and C) of the clay layer. The remaining curves, for the sand layer, are generated at: the sand-clay boundary; at effective D/B equal to 15 (first integer multiple of 5); at succeeding increments of effective D/B equal to 5 until D/B is greater than 45; and at the pile tip. The tip reaction curve (page 60) corresponds to an effective D/B at the tip equal to 66.4.

62. Forces and displacements at the pile head and tip are shown in the summary on page 61. The summary indicates that ultimate side friction contribution (difference between head and tip forces) to pile capacity occurs at a pile head displacement of 0.708 in. Figure 16 shows the plots of tip and head settlement.

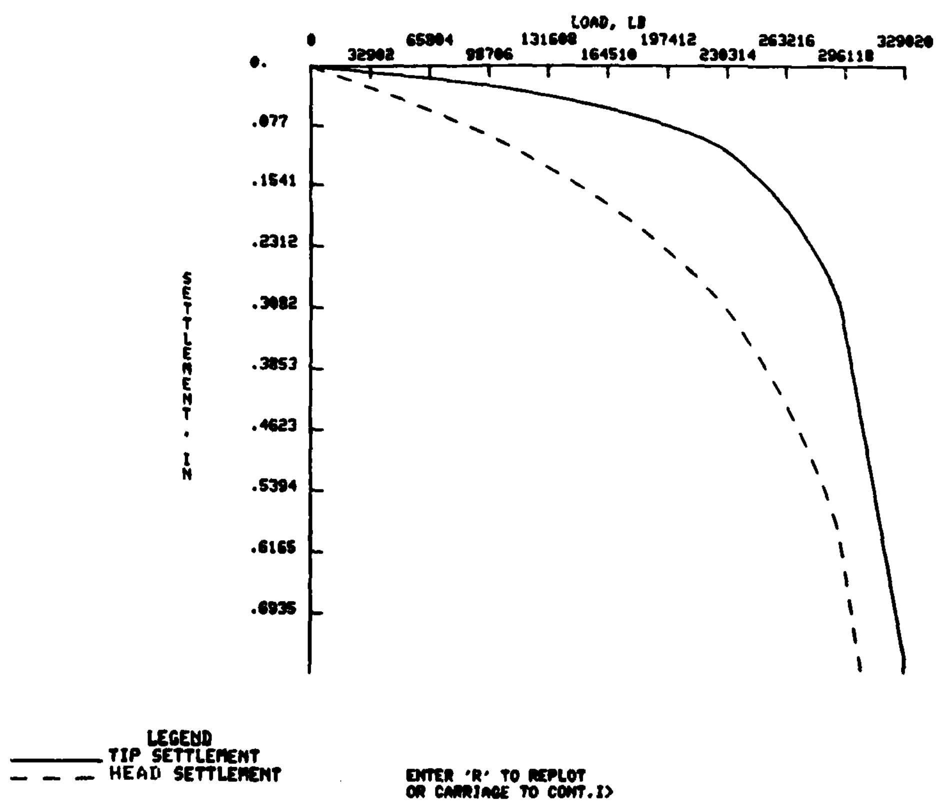

Figure 16. Plots of head and tip settlement, example 4

PROGRAM CAXPILE - SOIL-STRUCTURE INTERACTION ANALYSIS
OF AXIALLY LOADED PILES
DATE: 02/08/83 TIME: 09:09:26

I.--INPUT DATA

1.--HEADING

HP 14X89 PILE IN LAYERED SOIL
'TIP REACTION FROM SOIL DATA

2.--PILE DATA

<--ELEVATION--> START (FT)	STOP (FT)	MODULUS OF ELASTICITY (PSI)	OUTSIDE DIAMETER (IN)	SECTION AREA (IN)
0.00	-105.50	3.00E+07	18.16	26.10

3.--SIDE FRICTION SOIL AND WATER DATA
GROUND WATER UNIT WEIGHT = 0.0 (PCF)

SOIL LAYER DATA

		<-----TOP OF LAYER----->			<----BOTTOM OF LAYER--->		
TOP EL. (FT)	UNIT WEIGHT (PCF)	FRICT ANGLE (DEG)	COH. (PSF)	STRAIN 50% ULT.	FRICT ANGLE (DEG)	COH. (PSF)	STRAIN 50% ULT.
0.00	105.00		750.	.0100		750.	.0100
-27.00	130.00	30.0			30.0		

4.--TIP FORCE-DISPLACEMENT DATA

FROM SOIL DATA AT PILE TIP ELEVATION = -105.50 (FT)
EFFECTIVE TIP AREA = 204.00 (SQIN)

PROGRAM CAXPILE - SOIL-STRUCTURE INTERACTION ANALYSIS
OF AXIALLY LOADED PILES
DATE: 02/08/83 TIME: 09:09:44

II.--NONLINEAR CURVE DATA GENERATED BY CAXPILE

II.A.--HEADING
HP 14X89 PILE IN LAYERED SOIL
'TIP REACTION FROM SOIL DATA

II.B.--NONLINEAR CURVES FOR SIDE FRICTION
OBTAINED FROM SOIL DATA.

DISTRIBUTION STARTS AT ELEVATION 0.00 (FT)

CURVE COORDINATES

DISPL (FT)	FORCE (LBS/FT)
0.	0.
2.0833E-03	-4.2788E+02
3.1250E-03	-6.0617E+02
4.1667E-03	-8.2011E+02
5.5833E-03	-1.0697E+03
6.9167E-03	-1.2837E+03
8.3333E-03	-1.4263E+03
1.0417E-02	-1.6402E+03
1.2500E-02	-1.7829E+03
1.4583E-02	-1.8542E+03
1.6667E-02	-1.8898E+03
1.8750E-02	-1.9255E+03
2.0833E-02	-1.9611E+03

DISTRIBUTION ENDS AT ELEVATION -10.00 (FT)

CURVE COORDINATES

DISPL (FT)	FORCE (LBS/FT)
0.	0.
2.0833E-03	-4.2788E+02
3.1250E-03	-6.0617E+02
4.1667E-03	-8.2011E+02
5.5833E-03	-1.0697E+03
6.9167E-03	-1.2837E+03
8.3333E-03	-1.4263E+03
1.0417E-02	-1.6402E+03
1.2500E-02	-1.7829E+03
1.4583E-02	-1.8542E+03
1.6667E-02	-1.8898E+03
1.8750E-02	-1.9255E+03
2.0833E-02	-1.9611E+03

DISTRIBUTION STARTS AT ELEVATION -10.00 (FT)

CURVE COORDINATES

DISPL (FT)	FORCE (LBS/FT)
0.	0.
2.0833E-03	-6.0617E+02
3.1250E-03	-8.9143E+02
4.1667E-03	-1.2123E+03
5.5833E-03	-1.5333E+03
6.9167E-03	-1.8542E+03
8.3333E-03	-2.1394E+03
1.0417E-02	-2.5317E+03
1.2500E-02	-2.8169E+03
1.4583E-02	-2.9952E+03
1.6667E-02	-3.0665E+03
1.8750E-02	-3.1378E+03
2.0833E-02	-3.1735E+03

DISTRIBUTION ENDS AT ELEVATION -20.00 (FT)

CURVE COORDINATES

DISPL (FT)	FORCE (LBS/FT)
0.	0.
2.0833E-03	-6.0617E+02
3.1250E-03	-8.9143E+02
4.1667E-03	-1.2123E+03
5.5833E-03	-1.5333E+03
6.9167E-03	-1.8542E+03
8.3333E-03	-2.1394E+03
1.0417E-02	-2.5317E+03
1.2500E-02	-2.8169E+03
1.4583E-02	-2.9952E+03
1.6667E-02	-3.0665E+03
1.8750E-02	-3.1378E+03
2.0833E-02	-3.1735E+03

DISTRIBUTION STARTS AT ELEVATION -20.00 (FT)

CURVE COORDINATES

DISPL (FT)	FORCE (LBS/FT)
0.	0.
2.0833E-03	-1.9611E+03
3.1250E-03	-2.7099E+03
4.1667E-03	-3.3161E+03
5.5833E-03	-3.5657E+03
6.9167E-03	-3.4944E+03
8.3333E-03	-3.3874E+03
1.0417E-02	-3.3161E+03
1.2500E-02	-3.2805E+03
1.4583E-02	-3.2448E+03
1.6667E-02	-3.2091E+03
1.8750E-02	-3.2091E+03
2.0833E-02	-3.2091E+03

DISTRIBUTION ENDS AT ELEVATION -27.00 (FT)

CURVE COORDINATES

DISPL (FT)	FORCE (LBS/FT)
0.	0.
2.0833E-03	-1.9611E+03
3.1250E-03	-2.7099E+03
4.1667E-03	-3.3161E+03
5.5833E-03	-3.5657E+03
6.9167E-03	-3.4944E+03
8.3333E-03	-3.3874E+03
1.0417E-02	-3.3161E+03
1.2500E-02	-3.2805E+03
1.4583E-02	-3.2448E+03
1.6667E-02	-3.2091E+03
1.8750E-02	-3.2091E+03
2.0833E-02	-3.2091E+03

DISTRIBUTION STARTS AT ELEVATION -27.00 (FT)

CURVE COORDINATES

DISPL (FT)	FORCE (LBS/FT)
0.	0.
6.2500E-03	-6.4488E+02
1.0417E-02	-9.6732E+02
1.6667E-02	-1.1608E+03
2.5000E-02	-1.2898E+03
4.1667E-02	-1.2898E+03

DISTRIBUTION CONTINUES AT ELEVATION -27.89 (FT)

CURVE COORDINATES

DISPL (FT)	FORCE (LBS/FT)
0.	0.
6.2500E-03	-6.5609E+02
1.0417E-02	-9.8414E+02
1.6667E-02	-1.1810E+03
2.5000E-02	-1.3122E+03
4.1667E-02	-1.3122E+03

DISTRIBUTION CONTINUES AT ELEVATION -35.46 (FT)

CURVE COORDINATES

DISPL (FT)	FORCE (LBS/FT)
0.	0.
6.2500E-03	-7.3691E+02
1.0417E-02	-1.1054E+03
1.6667E-02	-1.3264E+03
2.5000E-02	-1.4738E+03
4.1667E-02	-1.4738E+03

DISTRIBUTION CONTINUES AT ELEVATION -43.03 (FT)

CURVE COORDINATES

DISPL (FT)	FORCE (LBS/FT)
0.	0.
6.2500E-03	-8.3200E+02
1.0417E-02	-1.2480E+03
1.6667E-02	-1.4976E+03
2.5000E-02	-1.6640E+03
4.1667E-02	-1.6640E+03

DISTRIBUTION CONTINUES AT ELEVATION -50.59 (FT)

CURVE COORDINATES

DISPL (FT)	FORCE (LBS/FT)
0.	0.
6.2500E-03	-8.7003E+02
1.0417E-02	-1.3050E+03
1.6667E-02	-1.5661E+03
2.5000E-02	-1.7401E+03
4.1667E-02	-1.7401E+03

DISTRIBUTION CONTINUES AT ELEVATION -58.16 (FT)

CURVE COORDINATES

DISPL (FT)	FORCE (LBS/FT)
0.	0.
6.2500E-03	-9.2708E+02
1.0417E-02	-1.3906E+03
1.6667E-02	-1.6688E+03
2.5000E-02	-1.8542E+03
4.1667E-02	-1.8542E+03

DISTRIBUTION CONTINUES AT ELEVATION -65.73 (FT)

CURVE COORDINATES

DISPL (FT)	FORCE (LBS/FT)
0.	0.
6.2500E-03	-9.5086E+02
1.0417E-02	-1.4263E+03
1.6667E-02	-1.7115E+03
2.5000E-02	-1.9017E+03
4.1667E-02	-1.9017E+03

DISTRIBUTION CONTINUES AT ELEVATION -73.29 (FT)

CURVE COORDINATES

DISPL (FT)	FORCE (LBS/FT)
0.	0.
6.2500E-03	-9.5086E+02
1.0417E-02	-1.4263E+03
1.6667E-02	-1.7115E+03
2.5000E-02	-1.9017E+03
4.1667E-02	-1.9017E+03

DISTRIBUTION CONTINUES AT ELEVATION -80.86 (FT)

CURVE COORDINATES

DISPL (FT)	FORCE (LBS/FT)
0.	0.
6.2500E-03	-9.5086E+02
1.0417E-02	-1.4263E+03
1.6667E-02	-1.7115E+03
2.5000E-02	-1.9017E+03
4.1667E-02	-1.9017E+03

DISTRIBUTION CONTINUES AT ELEVATION -88.43 (FT)

CURVE COORDINATES

DISPL (FT)	FORCE (LBS/FT)
0.	0.
6.2500E-03	-9.5086E+02
1.0417E-02	-1.4263E+03
1.6667E-02	-1.7115E+03
2.5000E-02	-1.9017E+03
4.1667E-02	-1.9017E+03

DISTRIBUTION CONTINUES AT ELEVATION -95.99 (FT)

CURVE COORDINATES

DISPL (FT)	FORCE (LBS/FT)
0.	0.
6.2500E-03	-9.5086E+02
1.0417E-02	-1.4263E+03
1.6667E-02	-1.7115E+03
2.5000E-02	-1.9017E+03
4.1667E-02	-1.9017E+03

DISTRIBUTION CONTINUES AT ELEVATION -103.56 (FT)

CURVE COORDINATES

DISPL (FT)	FORCE (LBS/FT)
0.	0.
6.2500E-03	-9.5086E+02
1.0417E-02	-1.4263E+03
1.6667E-02	-1.7115E+03
2.5000E-02	-1.9017E+03
4.1667E-02	-1.9017E+03

DISTRIBUTION ENDS AT ELEVATION -105.50 (FT)

CURVE COORDINATES

DISPL (FT)	FORCE (LBS/FT)
0.	0.
6.2500E-03	-9.5086E+02
1.0417E-02	-1.4263E+03
1.6667E-02	-1.7115E+03
2.5000E-02	-1.9017E+03
4.1667E-02	-1.9017E+03

II.C.--NONLINEAR CURVE FOR PILE TIP RESISTANCE OBTAINED FROM SOIL DATA.

CURVE COORDINATES

DISPL (FT)	FORCE (LBS)
0.	0.
8.3333E-03	-4.1933E+04
2.5000E-02	-7.8625E+04
6.2500E-02	-1.1532E+05
8.3333E-02	-1.1532E+05

PROGRAM CAXPILE - SOIL-STRUCTURE INTERACTION ANALYSIS
OF AXIALLY LOADED PILES
DATE: 02/08/83 TIME: 09:10:02

III.--SUMMARY OF RESULTS

III.A.--HEADING

HP 14X89 PILE IN LAYERED SOIL
'TIP REACTION FROM SOIL DATA

III.B.--DISPLACEMENTS AND FORCES

<--PILE HEAD-->		<--PILE TIP--->	
DISPL (IN)	FORCE (LB)	DISPL (IN)	FORCE (LB)
0.000	0.	0.000	0.
.110	115220.	.03[illegible]	13419.
.220	188385.	.070	29329.
.330	235820.	.121	45739.
.440	264945.	.192	58747.
.550	286148.	.270	73088.
.660	297369.	.362	83660.
.770	305293.	.459	91584.
.880	313218.	.556	99509.
.990	321142.	.653	107433.
1.100	329025.	.751	115317.
1.120	329025.	.771	115317.

MAXIMUM PILE HEAD FORCE - 329025. (LB)
AT DISPLACEMENT - 1.100 (IN)

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